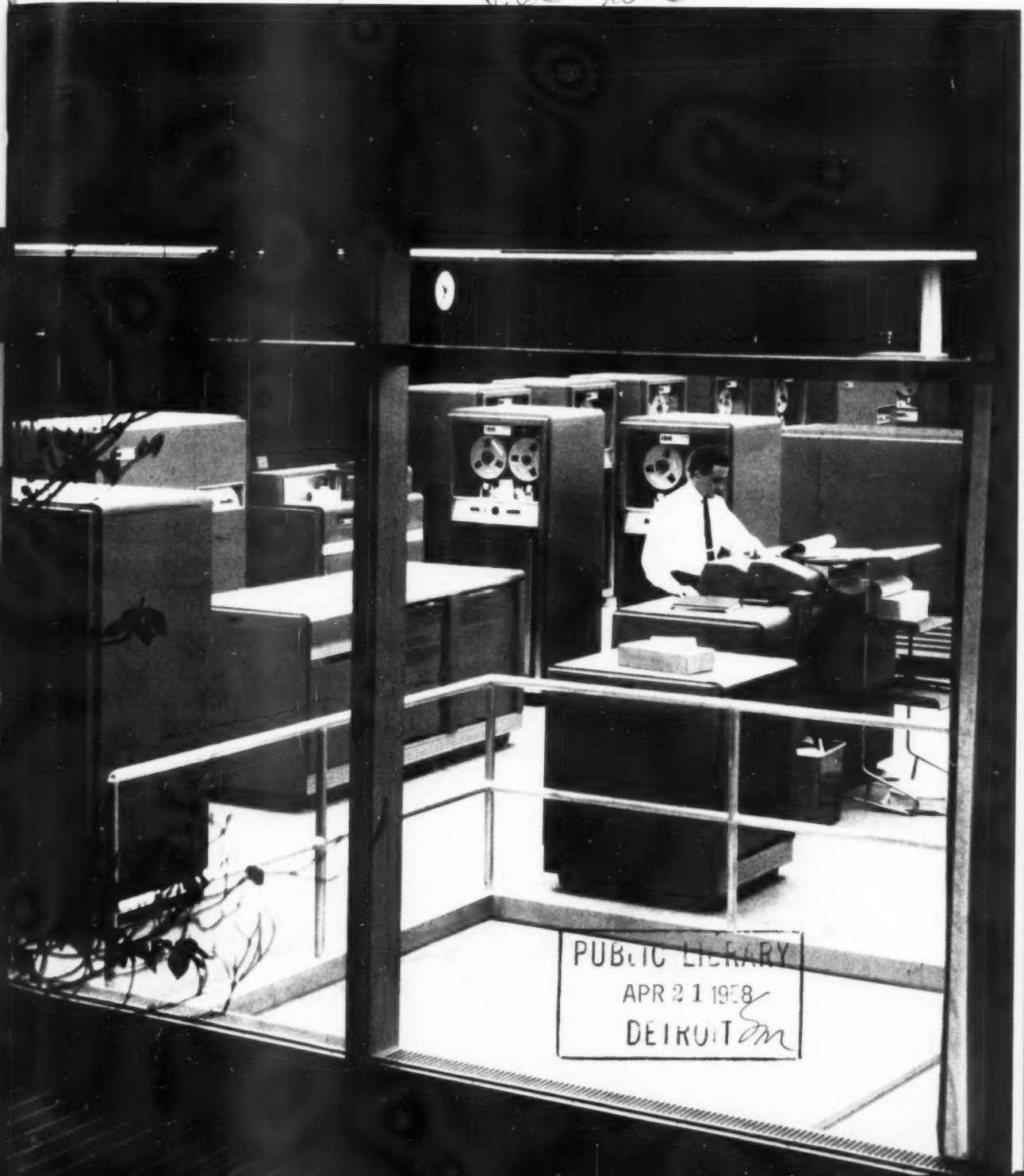
TECHNOLOGY DEPT.

TECHNOLOGY REVIEW

April 1958

v.60 no.6



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APR 21 1958
DETROIT

No. 4 in a series

Right off the Wire

Power for earth satellites could be supplied by a new chemical battery that uses a dye to convert sunlight into electricity.

A new bearing metal of tin and aluminum is said to combine the bearing qualities of one with the light weight of the other.

Negatively ionized air is being used as a painkiller for patients with severe burns. After two exposures of twenty minutes each no narcotics are needed.

Users of High Voltage cables should note that high molecular weight polyethylene can be expected to have a voltage life about seven times that of standard polyethylene. (From paper on Dielectric Strength and Voltage Life of Polyethylene, presented at AIEE Winter General Meeting, February 1958, by Messrs. Hunt, Ware and Koulopoulos of Simplex.)

A new, automatic door opener is installed overhead, like a door check, and requires no complex, under-floor wiring. It can be installed in a few hours.

In a new cook stove the heat is generated in the utensil by putting it in a magnetic field. No heat is wasted and spilled food does not burn. It is said to be faster than ordinary electric stoves.

The "cage zone" melting system has proved successful in purifying niobium. Under high vacuum the metal is melted by high frequency current and the impurities separate to be cut off later.

A vinyl lining material for swimming pools of masonry or wood is in the form of sheeting with an adhesive back that sticks to the sides and assures complete waterproofing.

To meet the growing demand for power by industry, Simplex has installed new equipment that allows cable cores of greatly increased diameters to be armored with CONDEX, the interlocking armor tape made by Simplex since 1924.

Printed pages can actually be made to talk by means of a Japanese invention. The back of the paper is treated like magnetic tape and produces recorded sounds when a reproducing head is passed over the printed words.

Further information on these news items and on Simplex cable is available from any Simplex office. Please be specific in your requests.

A new, thirty-nine-passenger bus for intercity service is claimed to have many advantages. It has a flat floor (no step-up to seats), a "recreation area," lavatory, reclining seats and air suspension.

The size of electrical components may be further reduced by a process for putting tiny germanium transistors into printed circuits.

Buildings are being erected with the use of balloons instead of derricks.

A method of projecting color pictures on a screen from black and white slides has been discovered.

An acknowledged leader of the cable industry in research and manufacturing skills, Simplex scientists and engineers present technical papers on a variety of subjects of interest to users of insulated cables. A list of papers read before the AIEE and other associations will be sent on request.

Underwater nerves take the "miss" out of missiles

Test rockets fired from the U. S. Air Force Test Range in the Bahama Islands are tracked electronically from a series of check points along their routes. This close observation detects the slightest variance from the missiles' intended flight path. The vital communications link for this work is a 1400-mile Simplex submarine cable to Puerto Rico — a product of the world's most modern techniques in under-water cable manufacture.

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THE
Public
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First test firing of the ATLAS ICBM at Cape Canaveral, Florida, June 11, 1957.

Honeywell Rate Gyro
Type JRT
Shown ½ size

Flight Control for the ultimate weapon

Three Honeywell Rate Gyros, Type JRT, provide missiles with precise three-axis directional stability and are currently being supplied to the ATLAS missile program.

The Type JRT is a highly accurate precision instrument for measurement of absolute rates of rotation in inertial space. Viscous damping is electro-mechanically controlled to maintain a constant damping ratio over the entire operating temperature range of −65°F. to +175°F.

This new Honeywell Rate Gyro is designed expressly for flight control of missiles and flight instrumentation in missiles and aircraft where severe ambient conditions prevail . . . and at the same time where low threshold, minimum hysteresis, excellent linearity, high natural frequency and ruggedness are essential.

Honeywell inertial components and engineering experience are available to assist in the solution of your Gyro system problems. Write for Bulletin JRT . . . Minneapolis-Honeywell, Boston Division, Dept. 1, 1400 Soldiers Field Road, Boston 35, Mass.

Honeywell

Military Products Group

DESCRIPTIVE DATA

- **EXCELLENT LINEARITY:** 0.25% of full scale.
- **LOW HYSTERESIS:** Less than 0.1% of full scale.
- **LOW THRESHOLD:** Less than 0.01 degree/second.
- **MICROSYN PICKOFF:** Variable reluctance type providing infinite resolution and high signal-to-noise ratio.
- **FULL SCALE RATE:** Up to 1000 degree/second.
- **FULL SCALE OUTPUT:** Up to 12 volts.
- **RUGGED:** Withstands 100 G shock.
- **VIBRATION:** Withstands 15 G to 2000 cps.
- **SIZE:** 2 7/64" diameter 4 5/16" long.
- **WEIGHT:** 2 lbs.

THE TECHNOLOGY REVIEW, April, 1958, Vol. LX, No. 6. Published monthly from November to July inclusive at Emmett Street, Bristol, Conn., Publication date: twenty-seventh of the month preceding date of issue. Annual subscription, $4.00: Canadian and Foreign subscription, $4.50. Entered as second-class matter December 23, 1949, at the Post Office, at Bristol, Conn., under the Act of March 3, 1879.

In the manufacture of office machines, Olivetti controls every step of production; even many machines and tools used in making parts are Olivetti-made. This permits close quality-control and results in exceptionally high standards of precision and dependability. On most Olivetti machines the guarantee period is a full year instead of the usual 90 days.

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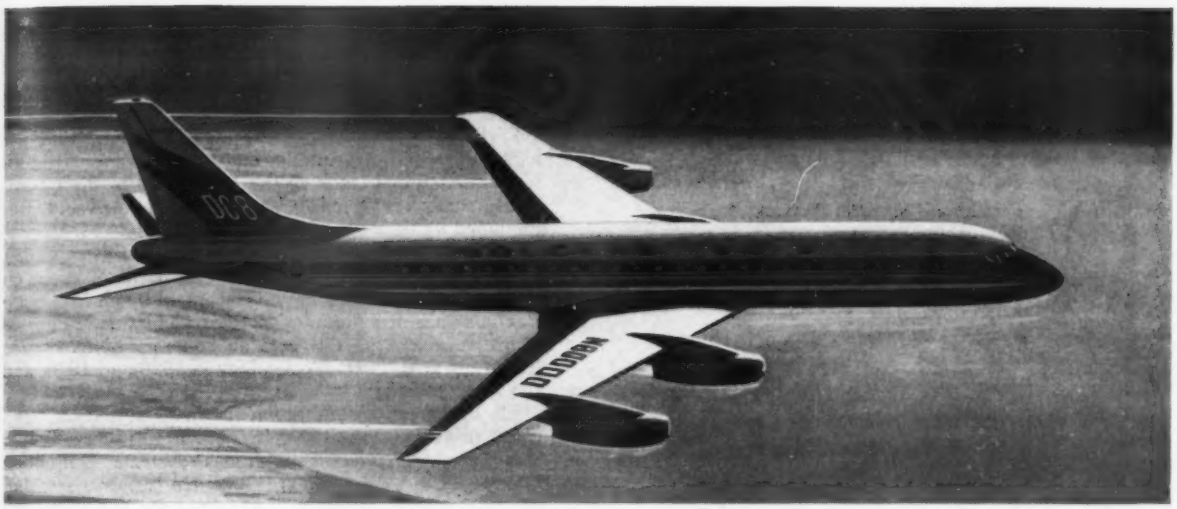
olivetti

The Olivetti Divisumma 24 high-speed printing calculator carries figures forward, combining many individual computations into a single continuing calculation. This eliminates re-entries, a common source of error, and saves time. The machine, with its single 10-key keyboard and unique automatic constant and memory, is easy to operate.



REQUIRED: A lightweight, low-loss, radiation-free cable with electrical uniformity for interconnecting the navigation and communication antenna circuits of the Douglas Aircraft Co.'s new DC-8 jet airliner.

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A semi-flexible cable with tubular copper inner conductor, foamed polyethylene dielectric and commercially pure aluminum outer conductor.

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4. Greater efficiency and improved system performance without the use of additional electronic components.
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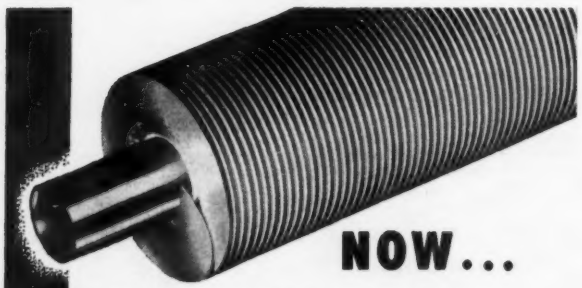

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THE TABULAR VIEW

Live Talent and Dead Reckoning. — For all their lightning speed in turning out computations, modern digital computers (such as the I.B.M. 704 in the Compton Laboratories) need to be properly directed and programmed by their users. As PROFESSOR PHILIP M. MORSE, Director of the Computation Center, relates (page 299) in "Teaching Machines to Reckon," months of effort on the part of live talent may be consumed by an inanimate machine in a few minutes' actual calculation. Professor Morse received the B.S. and an honorary Sc.D. degree from Case Institute of Technology in 1926 and 1940, and the M.A. and Ph.D. degrees from Princeton in 1927 and 1929. He joined the M.I.T. Faculty in 1931, and has been a full professor since 1939. In 1949 Professor Morse became research director, Weapons Systems Evaluation Group of the Joint Chiefs of Staff. He is now a member of the Scientific Advisory Committee for the Ordnance Department and the Bureau of Standards, and since 1955, director of the Institute's Computation Center.

Business and Education. — The interdependence of business and education is ably pointed out (page 305) by EDWARD MCSWEENEY, '23. Clearly aware of the feed-back loop that is necessary for our technology to operate, Mr. McSweeney urges growing support of education, by industry, as the logical means for industry to best advance its own needs. Mr. McSweeney has had wide experience in the business, management, and publications fields, with several stints in governmental public service. He is vice-president and treasurer of the Perkins-Goodwin Company of New York, and is also director of Amerace Corporation, MacFadden Publications, Inc., National Blank Book Company, and Southland Paper Mills, Inc. He is a member of several management associations, and consultant to American Legion Publications Commission. He is author of "Organization for More Efficient Management" (as well as numerous journal articles on organization and business problems), and has been guest lecturer at New York University and Northwestern University.

Equus Caballus. — Along with the American bison, the draft horse may be on its way to extinction after playing a major role in the nation's development. Thus thinks The Review's perennial contributor (page 307), FREDERIC W. NORDSIEK, '31. A reasonably complete biographical sketch of Mr. Nordsiek appeared on page 138 of the January, 1958, issue. As an item of news, we are able to report, however, that Mr. Nordsiek is busily engaged in making the conversion from "hunt-and-peck" typing to the more classical touch system, as an avocation from his post as administrator for the American Cancer Society.

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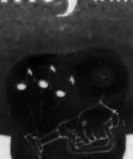

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MAIL RETURNS

INVENTIONS IN FLIGHT

FROM PROFESSOR EDWARD S. TAYLOR, '24:

The article "Invention in Flight" in The Review for February, 1958, contains a number of misleading statements. On a 1,000-mile flight on any of a number of air lines which fly Douglas DC-7 airplanes, regular cruising speed is 365 miles per hour, not 300 m.p.h. as stated. The Ram Jet is a completely worthless power plant at 750 miles per hour. It is necessary to fly more than twice this speed before this power plant becomes interesting at all.

The most glaring error, however, is the statement that "his (Langley's) airplane was successful *in all respects but power plant.*" As a matter of fact, the Manly engine used in the Langley airplane was an outstanding success. This engine produced 52 horsepower for 10 consecutive hours for a weight of 124 pounds. For comparison, the Wright brothers' engine developed 12 horsepower and weighed 180 pounds. I refer Dr. Blizard to "The Manly Engine" published by the Society of Automotive Engineers (1942) "for the purpose of making accessible to all who are interested in aircraft engines, the extraordinary pioneer work of Charles M. Manly in the development of the first successful light-weight internal-combustion engine. It is so seldom that an engineer is able to contribute more than a small step in the development of such a complicated mechanism as an aircraft engine, that we must pause in awe and profound respect for an engineer, who, at a time when the greatest of the world's engineers denied the possibility of an engine weighing less than 10 pounds per horsepower, developed a successful radial engine with an odd number of cylinders, which weighed less than 3 pounds per sustained horsepower, a performance which was not surpassed until the advent of the Liberty engine."

Professor of Aircraft Engines
M.I.T., Cambridge 39, Mass.

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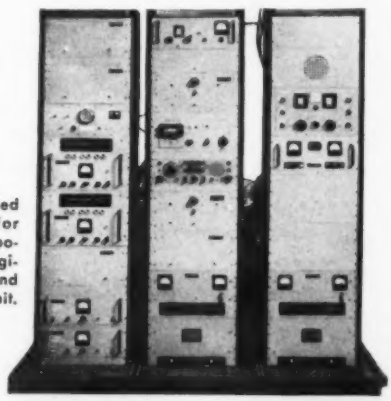
. . . from miniature components

Pioneers in the design and development of high frequency Crystal Filters in the 10Kc to 30Mc range, Hycon Eastern has worked closely with the electronics industry to reduce costs and make mass production runs practicable (more than 4,000 units delivered to date). Greatly simplifying electrical circuits, the Crystal Filter improves communications equipment by substantially reducing the need for multiple conversions as well as increasing the accuracy of frequency selections. *Write for Crystal Filter Bulletin.*



Timing System designed and manufactured for General Electric incorporating Hycon Eastern Digital Timing Generator and Magnetic Tape Search Unit.

. . . to complex systems

Locating specific data on magnetic tape units had been an unwieldy and time-consuming procedure. To solve this difficulty, Hycon Eastern engineers designed two companion units for high speed access to selected data in magnetic tape recorders and multi-channel magnetic tape instrumentation systems. The Digital Timing Generator, Model 201, generates numerically coded signals which are recorded throughout the data recording periods, providing a precise index. Based on indices recorded by the Digital Timing Generator, the Magnetic Tape Search Unit, Model 202, automatically selects for controlled playback the data specified by panel dial settings. Model 202 may be modified to search for timing formats other than those originated by Model 201. Model 206A (not shown) is a militarized version of Model 201 for airborne applications. *Write for Technical Bulletin TSG.*

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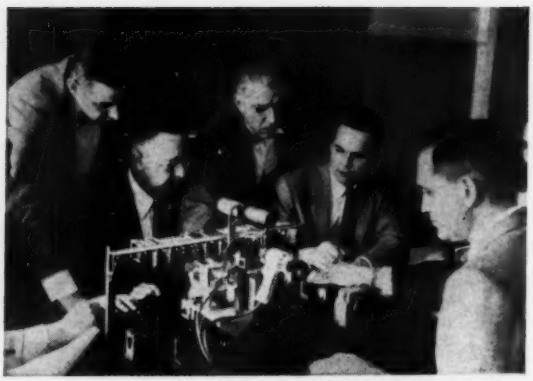
75 Cambridge Parkway Dept. H Cambridge 42, Mass.



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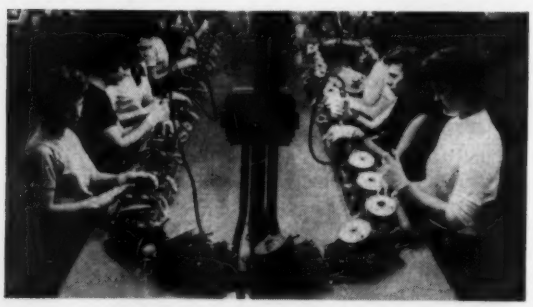

Opportunities spring from the work we do. As the Bell System's manufacturing unit, Western Electric is the world's largest maker of communications equipment. We are equipped to produce some 65,000 different parts which are assembled into a vast variety of apparatus and equipment. Add to this our steady, varied defense assignments, and you see why engineering skill gets top priority here at Western Electric.

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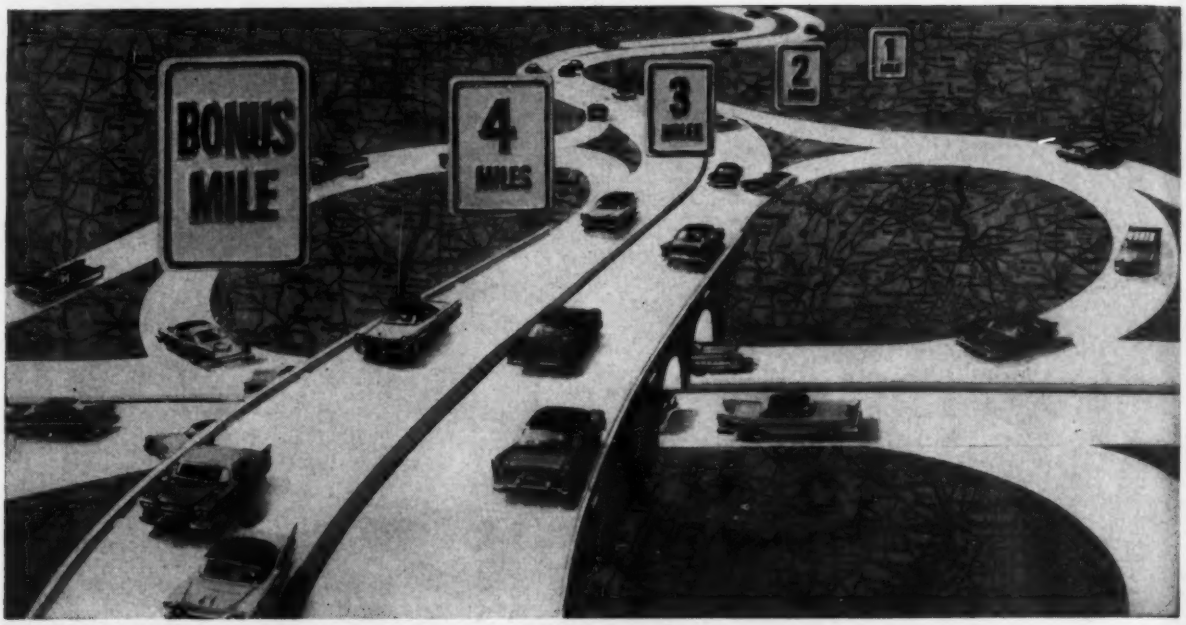
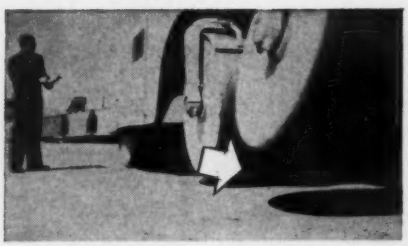
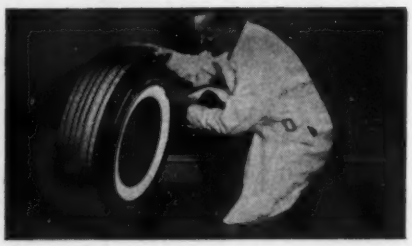


3-T Nylon makes it stronger... new thicker, wider tread plus new pre-shaping process makes it last 26% longer!



Look! 40,000 lbs. of pressure could not break Goodyear's triple-tough 3-T Nylon Cord. Reason: This nylon cord is triple-tempered under precise *tension*, at closely controlled *temperature*, for an exact period of *time*.

Result: A stronger, safer tire for more worry-free miles. See it soon at your Goodyear dealer's.



You can see why you get bonus miles ... the huskier non-skid tread and new traction design. And the tire is "pre-shaped" to its proper inflated size to relieve undesirable tension; pre-fit it for the road.

That means: Safer traction and surer stops ... and up to 26% longer wear. Goodyear, Akron 16, Ohio.

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THE TECHNOLOGY REVIEW

EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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Pont du Gard, aqueduct built by Romans, near Nimes, southern France.

Photograph by Paul L. Rittenhouse

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Not the Moon . . .

apparently disintegrating, but a silhouette of fragments from a dynamite explosion photographed by Harold E. Edgerton, '27, Professor of Electrical Measurements. At exposure time of about 1/20th of a microsecond, a Number 6 dynamite cap in one-inch hole in a steel tube (two-inches diameter) explodes. V-shaped wake (upper half of picture) indicates fragments' high velocity.

The Technology Review

VOL. 60, NO. 6 APRIL, 1958

The Trend of Affairs

Nuclear Engineering

■ A Department of Nuclear Engineering, to educate students in the peaceful application of atomic energy, is to be established at the Institute, according to a recent statement by Julius A. Stratton, '23, Acting President. Manson Benedict, '32, Professor of Nuclear Engineering, has been appointed head of the new Department which will be established on July 1.

The $2,640,000 nuclear reactor at M.I.T., which will be completed this spring, will serve as a laboratory for the new Department, enabling students to make firsthand studies of atomic energy produced by the fission process. Subjects taught will also include fusion, the nuclear reaction which occurs in the sun and stars and which is regarded as an inexhaustible power source for the future.

The Department of Nuclear Engineering, first in any New England college and one of the first in the United States, is the outgrowth of several years of experience in nuclear engineering at M.I.T. It will be a division of the School of Engineering, of which C. Richard Soderberg, '20, is dean. The teaching program will dovetail with a research program, which will include studies of atomic energy for medical and industrial, as well as scientific, purposes.

In the next two years, the demand for engineers and scientists in atomic energy work will nearly double, Dean Soderberg said. This estimate is based on a survey, made in 1957 for the Atomic Energy Commission by the Atomic Industrial Forum, showing that about 9,000 scientists and engineers were employed by industry in privately supported atomic energy activities. By 1960, industry expects to need 16,000 technically trained persons.

"Not only is there a rapidly increasing demand, but there is an exceptional demand for men of high abilities," Dean Soderberg said. "Nuclear engineering is a complex subject and requires competence in physics, chemistry, metallurgy, chemical, electrical, and mechanical engineering and other fields. At M.I.T. we hope to train the men who will be leaders in atomic energy.

"The students we must educate now are the ones who will discover new ways of using atomic energy — ways of which perhaps we have not even dreamed," said Dean Soderberg.

The first course in nuclear engineering was offered at M.I.T. in 1952 and since that time other courses have been developed, under the leadership of Walter G. Whitman, '17, Head of the Department of Chemical Engineering. Meanwhile, expansion in such fields as experimental and theoretical physics, research in nuclear fusion, and engineering applications of nuclear energy, clearly indicated the need for a separate course in nuclear engineering. To promote study and research in this field, the Institute has recently built a nuclear reactor which will go into operation this spring.

The new M.I.T. reactor is intended for research, teaching, and medical therapy, and is not designed for the generation of power. Nevertheless, students receiving degrees in the new Department will be prepared to carry on professional work in the design and operation of power reactors, among other things.

Study in the new Department will require prerequisites of physics, mathematics, and engineering, Dean Soderberg said. Classes will be open to undergraduates but the Department will give degrees only for graduate work. Subjects to be studied in the Department of Nuclear Engineering will include: the theory of nuclear reactions and their means of production; design and construction of nuclear reactors, including cooling and control systems; shielding against harmful radiation; biological effects of radiation; nuclear metallurgy; nuclear chemical technology; heat transmission; and instrumentation. In addition to classes in Cambridge, nuclear engineering students may attend the Engineering Practice School conducted by M.I.T. at Oak Ridge, Tenn.

This year 94 students — including 17 foreign students — have been registered for graduate study in nuclear engineering. Of these, 23 are from M.I.T. and the rest have come from 49 other institutions, including Annapolis and West Point.

Professor Benedict came to M.I.T. in 1951 at the time a decision was made for the Institute to enter the field of nuclear engineering. He was joined in 1955 by Theos J. Thompson, Associate Professor of Nuclear Engineering, who has directed the design

Class Reunions in 1958

Class	*Date*	*Place*	*Reunion Chairman or Class Secretary*
1893	June 16	Luncheon—M.I.T. Campus	George B. Glidden, Centre Street, R.F.D., N. Dighton
1898	June 17	To Be Announced Later	Edward S. Chapin, The Eliot, 370 Commonwealth Avenue, Boston 15
1900	June 17-19	The Pines, Cotuit	Elbert G. Allen, 11 Richfield Road, W. Newton 65
1903	June 14-15	Burton House, M.I.T., Cambridge	LeRoy B. Gould, 36 Oxford Road, Newton Center 59
1908	June 13-15	*50th Reunion* Snow Inn, Harwich Port	Leslie B. Ellis, 230 Melrose Street, Melrose 76
1913	June 13-15	Oyster Harbors Club, Osterville	William R. Mattson, 28 Brookdale Road, Newtonville 60
1916	June 13-15	Chatham Bars Inn, Chatham	Harold F. Dodge, 96 Briarcliff Road, Mountain Lakes, N.J.
1918	June 13-15	The Treadway Inn, No. Falmouth	John W. Kilduff, Estes Street, Amesbury
1923	June 12-15	The Pines, Cotuit	Wentworth T. Howland, 1771 Washington Street, Auburndale 66
1928	June 13-15	Marshall House, York Harbor, Maine	Walter J. Smith, 209 Waverly Street, Arlington 74
1933	June 14-16	*25th Reunion* Baker House, M.I.T., Cambridge	Charles C. Bell, 180 Wamponoag Road, E. Greenwich, R.I.
1938	June 14-15	Chatham Bars Inn, Chatham	John R. Cook, Wendling Farm, Williamstown
1943	June 13-15	Royal Club Hotel, Megansett Beach, Falmouth	Ralph E. Leader, 123 Country Way, Needham
1948	June 13-15	Curtis Hotel, Lenox	Robert H. Bliss, 55 Arbor Street, Wenham
1953	June 14-15	Wentworth-by-the-Sea, Portsmouth, N.H.	Marion C. Manderson, 100 Martin Street, S. Acton

and construction of the M.I.T. reactor. Other members of the new Department will include: Professor Irving Kaplan, Edward A. Mason, '48, Associate Professor of Nuclear Engineering; Melville Clark, Jr., '43, and Gordon L. Brownell, '50, Assistant Professors of Nuclear Engineering.

Dr. Benedict began his career as a physical chemist and acquired experience in nuclear engineering through wartime necessity. As a worker for the Manhattan Project, he participated in the first important nuclear engineering project, the production of atomic bombs.

Born in Lake Linden, Mich., Professor Benedict was graduated from Cornell University in 1928 and did his graduate work at M.I.T., receiving a Ph.D. degree in 1935. He was a research fellow at Harvard University before going into industry as a chemist.

In 1942 Dr. Benedict was asked to take charge of the process design of the gaseous diffusion plant for the concentration of Uranium^{235}, built at Oak Ridge.

In 1946, Dr. Benedict was chairman of the Technical Committee on Inspection and Control of Atomic Energy of the War Department. Since 1947, he has served on the Reactor Safeguard Committee of the A.E.C. He was an adviser to the U.S. delegation at the Atoms for Peace Conference in Geneva in 1955.

Dr. Benedict serves as a consultant to National Research Corporation and the General Atomic Division of General Dynamics Corporation, and is a director of the Nuclear Science and Engineering Corporation. He is a fellow of the American Academy of Arts and Sciences, a member of the National Academy of Sciences, and a director of the American Institute of Chemical Engineers.

Placement and Deep-Sea Findings

■ Gilbert M. Roddy, '31, President, opened the 329th meeting of the Alumni Council held at the Faculty Club on Monday, February 24, which was attended by 141 members and guests. In introducing those at the head table, President Roddy presented a gavel to Theodore T. Miller, '22, as a token of appreciation and congratulations for his term as 63d President of the Association for the year 1956–1957.

Donald P. Severance, '38, Secretary of the Association, made the report for the chairman of the National Nominating Committee — Horatio L. Bond, '23, who was unable to be present. Nominees, named by this committee, were reported in the March, 1958, issue of The Review (page 241). Candidates named to serve on the National Nominating Committee (reported in The Review last month) were also listed; so, too, were candidates of classes whose numerals end in four or nine, to serve five-year terms as Class Representatives on the Alumni Council.

It was reported that between January 15 and February 6, seven members of the Institute's staff had visited eight M.I.T. clubs in Montreal and the northeast portion of the United States. Nominations for members to serve on the Afternoon Program and the Banquet Subcommittees of the 1958 Alumni Day Committee were also approved.

As chairman of the Midwinter Meeting Committee, Vincent T. Estabrook, '36, reported that 479 Alumni and guests dined at Walker Memorial on February 4, and approximately 1,000 attended the program which followed at Kresge Auditorium. At least 50 per cent of those in attendance at the Midwinter Meeting

were superintendents, principals, school board members, and science teachers in secondary schools who had been especially invited to take part in the discussions of the work of the Physical Science Study Committee. It is felt that the Association has performed a real service to the Institute and to the Metropolitan Boston community in arranging the meeting on secondary school science teaching, as reported in The Review (March, 1958, page 250).

George Owen, '94, presented resolutions on Harry H. Young, '91, which were accepted by a standing, silent vote of the Council members.

Alf K. Berle, '27, reported that personal solicitations were well under way on a regional basis. In contrast to 73 regions organized last year, there are 153 regional organizations this year. Also reported by Mr. Berle was the fact that, as of February 21, a total of 8,933 Alumni had contributed more than $291,000 to the 1958 Alumni Fund. This figure compares with 8,671 Alumni who had contributed $257,000 at the corresponding time a year ago. Of the Council members, 87 per cent had contributed to the Alumni Fund by February 21, and it was urged that the Council reach 100 per cent participation as soon as possible.

After the business portion of the meeting, Thomas W. Harrington, Jr., Placement Officer at the Institute, spoke on "The Outlook for Engineers" and Harold E. Edgerton, '27, Professor of Electrical Measurements, spoke briefly on "Camera Explorations in the Sea."

Mr. Harrington spoke of the role of the Placement Bureau in providing for student and Alumni interviews for the 450 companies who each year interview at M.I.T., and of the Placement Library. He said there has been a very noticeable change in the emphasis by companies. Although there is a reduction in the overall demand, almost as many companies are interviewing at M.I.T. as last year, but, this year they are seeking the top of the country's collective graduating class, and there has been very little upward change in starting salaries.

Mr. Harrington spoke of the relationship between the recession and its softened job market and the much publicized "engineering shortage." Today, in certain fields, notably electronics and aircraft, there is apparently little shortage in the hiring of new graduates, although there is some shortage of experienced men. Shortages still exist among small companies. He anticipated that the demand will again increase in all areas as the country pulls out of the recession.

Dr. Edgerton showed a fascinating reel of color motion pictures which were made during a recent expedition on the *Calypso* with Commandant Jacques Y. Cousteau to the Romanche Depth in the Atlantic. Halfway between Africa and South America, on the Equator, their ship anchored in 25,000 feet of water with one-half inch nylon for the "anchor chain." The pictures showed the crew paying out the nylon anchor line, as well as another nylon line on which Dr. Edgerton's deep-sea automatic camera was lowered to obtain photographs of the ocean floor at a depth of about five miles. Dr. Edgerton also presented two pictures which were taken at 24,600 feet, showing some small creatures about one and one-half inches long, a star fish, and, to the surprise of the oceanographers, a fairly rocky ocean bed!

On the Horizon

April 12, 1958 – Spring Dinner, M.I.T. Club of Philadelphia, Longwood Gardens, Kennett Square, Pa. **Speaker:** James R. Killian, Jr., '26, Special Assistant to the President for Science and Technology. (For reservations, consult Samuel K. McCauley, '41, P.O. Box 298, Upper Darby, Pa.)

June 16, 1958 – 24th Alumni Day, 1958, M.I.T., Campus in Cambridge.

November 8, 1958 – 13th M.I.T. Alumni Regional Conference, Albuquerque, N.M.

Russian Journals Translated

■ As part of a broad program to provide for freer exchange of scientific and technological information, English translations of three leading Russian journals in electronics and communications will shortly be available. These translations were made possible last summer by a $70,000 grant to M.I.T. by the National Science Foundation.

The grant is being administered by William N. Locke, Head of the Department of Modern Languages and Director of the M.I.T. Libraries, in collaboration with Jerome B. Wiesner, Director of the Research Laboratory of Electronics, and Robert M. Fano, '41, Professor of Electrical Communications.

The three Russian journals for which English translations will shortly become available are:

(1) *Radiotekhnika* (Radio Engineering);

(2) *Radiotekhnika i Elektronika* (Radio Engineering and Electronics); and

(3) *Elektrosviaz* (Radio Engineering and Telecommunications).

Translations for the Radio Engineering and Telecommunications and also for Radio Engineering and Electronics will begin with the January, 1957, issue. Translations for Radio Engineering will begin with the July, 1957, issue. The English editions are to be sold on a subscription basis, at a price ranging from $30 to $45 per volume, for libraries and commercial organizations, with 50 per cent off to individuals.

The Institute has let a contract to the Pergamon Press, Inc., a nonprofit organization with headquarters in New York, for translating, publishing, and distributing the journals.

The M.I.T. program, assuming responsibility for the radio and electronics portions of modern technology, is part of a larger program sponsored by the United States government to make English translations of Russian journals for use by scientists and engineers in industry, as well as in universities and government. Because relatively few technically trained personnel in the democratic nations speak or read Russian fluently, and because Soviet scientists are making important advances in the broad field of technology, the translation program is felt to be important to scientists and engineers of the free nations.

In March, copies of the first issue of *Radiotekhnika* to be made available in the English translation were received by Professor Locke, and should now be available to subscribers.

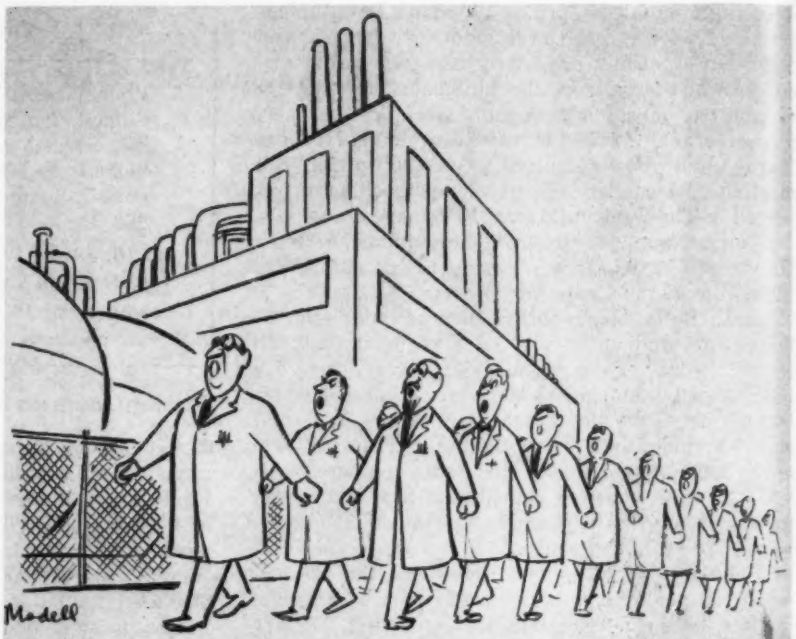
To See Ourselves As Others See Us

In addressing the Washington Regional Conference on March 1, Dean Harrison stated his belief that "Politicians, not scientists, must run the country, but they need to understand science to do it." At the same conference, Acting President Stratton emphasized the important "role of the engineer in our national progress." Scientists, it seems, have been coming out "second best."

But the New Yorker *evidently feels differently about the matter. Its January 18 issue contains the cartoon (shown at the right) which needs no further comment.*

It's a good thing, occasionally, to see ourselves through the eyes of the other person.

Altogether now — "From the halls of Montezuma, To the shores of Tripoli . . ."



"From the cyclotron of Berkeley to the labs of M.I.T.,
We're the lads that you can trust to keep our country strong and free."

Individuals Noteworthy

■ The early months of the year brought forth the following 21 promotions, elections, or appointments:

William F. Tuttle, '17, as Director of Engineering, Armco Steel Corporation . . . *Morris N. Lipp, '20,* as City Manager, Miami Beach, Fla. . . . *Harold H. Eder, '23,* as Ministro de Fomento, Republic of Colombia . . .

Henry Flynn, '23, as Manager, Port Arthur Refinery, The Texas Company . . . *Albert A. Gordon, 3d, '23,* as Manager of Manufacturing Engineering, Crompton and Knowles Corporation . . . *Walter F. Munford, '23,* and *Maxwell D. Millard, '33,* respectively, as Executive Vice-president for Engineering and Research, and as Administrative Vice-president — International, United States Steel Corporation . . .

Paul J. Cardinal, '24, as Vice-president in Charge of Industrial Relations, Hoffmann-La Roche, Inc. . . . *Edward J. Hanley, '24,* as a Director, Westinghouse Air Brake Company . . .

Charles M. Cooper, '25, and *Harcourt C. Vernon, '29,* respectively, as Assistant Division Director in Charge of the Engineering Research Laboratory, and as Director of that Laboratory, Development Engineering Division; and *Norman A. Copeland, '36,* as Assistant Director of Manufacture, Film Department, E. I. du Pont de Nemours and Company, Inc. . . .

Orrick H. Biggs, '26, as Vice-president of Engineering, Sylvania Lighting Products, Inc. . . . *John R. Kimberly, '26,* as President, American Pulp and Paper Association . . . *Stuart T. Martin, Jr., '34,* as President, Mount Mansfield Television, Inc., in the state of Vermont . . .

Marvin H. Gluntz, '35, as Executive Vice-president, H. C. Downer and Associates, Cleveland . . . *George P. Knapp, '35,* as Director of Engineering, Sanborn Company, Waltham, Mass. . . . *Leonard W. Kates, '43,* as Director of Engineering, Sylvania-Corning Nuclear Corporation . . .

William R. Zimmerman, '48, as Manager and Member of Board of Directors, American Envelope Company, West Carrollton, Ohio . . . *George A. Michael, '50,* as Chairman, Board of Registration of Sanitarians, Commonwealth of Massachusetts . . . *George B. Thomas, Jr.,* Associate Professor of Mathematics at the Institute, as First Vice-president, Mathematical Association of America.

■ Recent honors announced or presented to Alumni include:

To *Carl S. Ell, '11,* the New England Award, annually bestowed upon the area's outstanding engineer of the year, by the Engineering Societies of New England . . . to *Alfred J. Ferretti, '17,* the grade of Honorary Fellow, by the American Society of Mechanical Engineers . . . to *James H. Doolittle, '24,* an honorary doctorate in engineering, by the University of Michigan . . .

To *Alexander Squire, '39,* the Westinghouse Order of Merit "for his technical leadership and management ability in the development of the nuclear propulsion plant for fleet-type submarines . . .," by the Westinghouse Electric Corporation . . . to *Richard K. Pitler, '49,* the Frank B. Lounsberry Award, by the Allegheny Ludlum Steel Corporation. The Lounsberry Award was established in 1953 to give recognition to "technical accomplishment properly reported."

Twenty-five Years Ago This Month . . .

■ In a series of four departmental lectures, Professor Edward P. Warner, '17, traced recent trends in the field of air transportation. There had been, he observed, a substantial increase in the total of passenger miles flown, and the mileage of scheduled mail flying had shown a decided gain every year through 1931, with a slight reduction during 1932.

The safety record, as measured in passenger miles per fatality, had improved steadily, and the only foreign country with a record as good as the United States was Holland. The United States exceeded in volume the total commercial transportation of all other countries combined, and had nearly 10 times the amount of passenger transportation of its nearest competitor, Germany.

In aircraft design the most significant developments had been increased cruising speeds and passenger comforts. A gain in the average cruising speed of transport airplanes, from about 100 to 140 miles per hour, had been effected in the past few years. Improvements in passenger comfort centered largely around more adjustable seats, better ventilation, and better noise insulation of the cabin.

As to the future prospects of air transportation, he predicted that in the next 10 years air lines would handle 10 per cent of the total long-distance passenger travel of the United States, and would be self-supporting, without government subsidy in the form of mail contracts. The carriage of mail by air should increase steadily, depending somewhat upon legislation; and although air express will handle a relatively insignificant volume of the total amount of goods shipped, he thought it might become an important feature of the air-transportation system for shipments of an emergency nature.

■ In the advertising columns of The Review, The Technology Press announced publication of its first book — *Textile Research: A Survey of Progress*, which had been edited by a Board composed of 22 "leading authorities on research in the textile field." This first-born volume of the Press was, said the announcement, "reasonably priced at $2.50 postpaid."*

■ The Institute community mourned the tragic loss of four Alumni when the rigid airship U.S.S. *Akron* went down at sea on the morning of April 4, 1933 — George C. Calnan, '23, Herbert M. Wescoat, '29, Hammond J. Dugan, '32, and Joseph H. Severyns, '32.

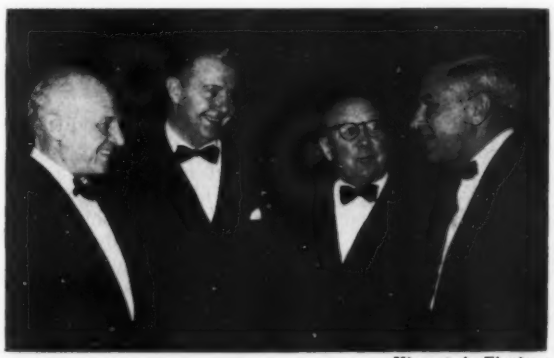
* From today's viewpoint other prices quoted in advertisements in the April, 1933, issue of The Review also seem "reasonable," for example, the North German Lloyd promised: "Now you can go to Europe in a two-weeks' vacation for $192 . . . by the *Bremen* and *Europa* . . . fastest liners afloat. All-expense tours." A year later, in the April, 1934, issue of The Review, Cadillacs were advertised at $2,395!

Washington Regional Conference

■ Frontiers of physics and biology were the principal subjects discussed at the 12th Regional Conference held at the Shoreham Hotel in Washington, D.C., on Saturday, March 1. The conference was arranged by co-operative efforts of the Institute, the Alumni Association, and the M.I.T. Club of Washington, and drew a total attendance of approximately 525 registrants, with about 425 present at the evening dinner.

In the past, regional conferences have attracted leading industrialists and educators. The Washington Conference was attended by a galaxy of scientists as well as high-ranking persons in the nation's civilian government and in the Armed Services. With problems of science of major national concern, the conference, whose theme was "The Outlook for Science in America," was not only exceptionally well received, but was most timely as well. Greetings from President Eisenhower were conveyed to the conference attendees by the Honorable James R. Killiam, Jr., '26.

Washington Alumni who took leading parts in the administration and planning of the conference included: Thomas K. Meloy, '17, conference chairman, and toastmaster at the luncheon and evening banquet; Robert W. Blake, Jr., '41, vice-chairman of the conference, and President of the M.I.T. Club of Washington; Adolphe H. Wenzell, '17, chairman, Financial Committee, and presiding officer at the morning technical session; Francis V. du Pont, '17, chairman, Invitations Committee, and presiding officer of the afternoon session; Thornton W. Owen, '26, chairman, Publicity Committee, and Charles S. Butt, Jr., '41, chairman, Arrangements Committee.



Vincent A. Finnigan

Thomas K. Meloy, '17, James R. Killian, Jr., '26, and Sir Robert Watson-Watt (left to right) appear amused at the remarks made by Lee A. DuBridge, President of the California Institute of Technology.

M.I.T. President James R. Killian, Jr., '26, currently on leave as Special Assistant to the President of the United States, and Julius A. Stratton, '23, Chancellor and Acting President of the Institute, spoke at the evening dinner. Sir Robert Watson-Watt, best known as the "Father of Radar," spoke at the noon luncheon on the topic, "Another Pearl Harbor in the West."

Taking part in addresses during the day, at which various phases of the physical and biological sciences were stressed, were: George R. Harrison, Dean of the School of Science; M. Stanley Livingston, Professor of Physics; and Francis O. Schmitt, Institute Professor and Professor of Biology; and Elbert P. Little, Executive Director, Physical Science Study Committee.

Vincent A. Finnigan

Left-hand portion of speakers' table at the luncheon included (left to right): Elbert P. Little, Executive Director, Physical Science Study Committee; George R. Harrison, Dean of Science; Francis V. du Pont, '17, who presided at afternoon session; James R. Killian, Jr., '26, who gave banquet address; and Sir Robert Watson-Watt, luncheon speaker. Right-hand portion of speakers' table included (in reading order): Thomas K. Meloy, '17, Conference Chairman; Julius A. Stratton, '23, Chancellor and Acting President of M.I.T., and banquet speaker; Adolphe H. Wenzell, '17, who presided at morning session; Francis O. Schmitt, Institute Professor; M. Stanley Livingston, Professor of Physics; and Robert W. Blake, Jr., '41, President, M.I.T. Club of Washington.

A brief summary of the addresses, as given in chronological order, is given below.

In the opinion of Dean Harrison, who spoke on "What's Ahead for Science?" politicians, not scientists, must run the country, but they need to understand science to do it. Dean Harrison said:

Despite the increasing importance of science to human welfare, scientists will not be the leaders of the America of tomorrow except as advisers. Scientists are trained specifically to avoid compromise among conflicting opinions, and to search for facts. The very essence of statesmanship is arrival at agreement when opinions are conflicting.

If our nation is to survive and to remain free, our leaders will be statesmen and politicians who have a much better understanding of the background, the aims, the methods, the potentialities, and the limitations of science and scientists.

In a democracy we obtain, in general, only leaders of the quality we deserve, and our need for new types of administrators points up the need for an enlightened citizenry, a larger proportion of which is able to meet the higher intellectual requirements of an atomic age.

The social sciences and humanities, as well as science, need emphasis, Dean Harrison said, but he asserted they should be related to science. He said:

Thus we need not only to educate more and better scientists, but to prepare the voters of tomorrow to understand the new world picture which science is revealing and has helped, willy-nilly, to produce. Our improvements in education must include not merely inducement for more students to go into science and help for those who wish to do so, but raising of the tone of general education and improvement of the disciplinary character of all subjects taught in primary and secondary schools, as well as the colleges.

Already, since the Sputnik scare which sobered us all and brought America up short, we are hearing negative reactions: the Russian schools are not really as good as ours, say some; we must not go overboard and neglect the humanities while advancing the sciences, say others; our public school teachers are not really so vastly underpaid, we are told; and we must not engage in a numbers race with the Russians.

All of these statements are to some degree true, but America is faced with a real and present danger, and the minor reservations must not be allowed to sap our determination to face and overcome this danger. Social scientists and other humanists will be needed in the new age as never before, but they should be more active in increasing their awareness of the dawn of this new age.

Intelligent anticipation of the future is equally important to contemplation of the history of the past. The study of the lives of ancient Greeks and Romans is reveal-

(*Continued on page 318*)

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At the evening banquet, those at the head table included (in usual order): James R. Killian, Jr., '26, Thomas K. Meloy, '17, toastmaster; Julius A. Stratton, '23, William H. Bates, Representative from Massachusetts; Gilbert M. Roddy, '31, President, Alumni Association; C. George Dandrow, '22, Past President, Alumni Association; and H. E. Lobdell, '17, Executive Vice-president, Alumni Association.

Fay Foto Service, Inc.

View of the machine area in the Computation Center. In the foreground from right to left are tabulator unit, card input, control board, and cathode-ray visual output. In the background are the magnetic tape units and the "off-line" equipment.

Teaching Machines to Reckon

Computers can count, and can store and compare data. But man must program and direct the machine in order to take advantage of its lightning-speed calculations

by PHILIP M. MORSE

VISITORS to the new Karl Taylor Compton Laboratories building seem to like to pause for a moment to look through the "store front" windows separating the first-floor corridor from the reception room and operating area of the new Computation Center which houses the various units of the recently installed I.B.M. 704 digital computer, made by the International Business Machines Corporation. Most days the scene in the air-conditioned interior displays activity, if not hectic animation. In the reception area nearest the corridor a half-dozen or more students and Faculty members will be dispersed, some hastily checking over operating instructions for the problem they wish the machine to solve, some poring over answers the machine has printed out on standard 15-inch wide report sheets, some awaiting their turn to use the computer, and some talking to colleagues or to a member of the Center staff.

Beyond the plush-cord line dividing the reception area from the operating area, the visitor can see the machine operator inserting decks of instruction cards in the card input unit or pushing buttons in response to the dancing red lights on the control console. Often the person whose problem is being run will be watching the lines of printed results as they come from the tabulation unit, eager to see the next line or dejectedly scanning evidence that something has gone wrong with the program. In the background, behind the card and tabulator units, can be seen the magnetic tape units. In some units tape reels are spinning, either to feed more data or instructions into the machine or to record results. In other units tape reels are being changed by an assistant. Over in the far left corner another group may be watching the "off-line-printer" transcribe from a tape the results of an earlier run.

Pushing through the door to the reception area, if he wins approval of the receptionist on duty, the visitor will perceive that the activity is not overly noisy; voices do not have to be raised much above conversational level except on occasions when the "on-line-printer" is particularly active. True, he is aware of the faint hiss of the air conditioning and the not-so-faint whir of the magnetic drum unit. But anyone acquainted with the deafening roar present in other computer installations will be surprised and pleased at the comparative quiet here. This result came not by chance. Each unit in a modern computer

Fay Foto Service, Inc.

View of control panel of the 704 computer. Colored buttons on the panel provide general operating controls, such as stop or start, read card, etc. Detailed instructions of the machine program are read from punched cards into the memory unit and from thence exercise high-speed control of the details of each computation. Buttons on the lower right-hand part of the panel may be programmed to provide other external controls as needed. Neon lights on the central part of the panel indicate the operation of various parts of the circuitry.

generates quantities of heat, which must be carried away or the machine would overheat in a few minutes. In most installations the cooling is achieved by flooding the area with cool air, then sucking this air into each unit as it comes by, and blowing it over the hot elements by means of a fan – a rather unimaginative method and a noisy one, for the unit fans cause 95 per cent of the noise! In the installation at the Institute the cooled air, at a slight excess pressure, is ducted directly to each machine so that no unit fans are needed, and the unit elements run actually cooler than in the usual installation. Fans have been eliminated from all major units except the magnetic drum, which now generates more noise than all the rest. As soon as arrangements can be made to remove the fans from this unit, the area will be as quiet as some of the libraries or other intellectual work areas at the Institute.

If the visitor finds his way down the stairs to the preparation room below, he will see more activity. Machine users are preparing cards by operating the typewriter keyboards of the card-punch machines, are duplicating cards from some standard-routine deck to insert in their own pile, or are running their cards through a sorter. In these various ways they get together (in the form of a set of holes punched in a deck of cards) the instructions, definitions, and data which tell the machine how to do their problem. If the dozen to a hundred holes are punched right on each card and if the 20 to 500 cards are in the right order, then the machine will translate the instructions and data into meaningful electronic activity, and will solve the posed problem in a hurry. The card deck is the user's means of telling the machine what he wants in a language the machine can understand.

But there is a long history of activity before the cards are punched and fed to the machine, which is not as apparent to the casual visitor as is the orderly bustle in the machine room. Some of it is being carried out all over the Institute as M.I.T. Faculty members translate their mathematical equations into instructions to punch onto cards, and as students struggle to state their thesis problems in a language appropriate for machine calculation. Some activity is being carried out, by visitors from other New England colleges, in the offices across the hall from the machine room, for the equipment at the Center has been donated by the International Business Machines Corporation for the use of all the colleges in New England.

At present, some two dozen New England colleges and universities are actively participating in a large-scale program aimed at introducing the use of electronic computers into the college curriculum. Each August a special two-weeks' course in coding is given by the Center staff to interested students and faculty members from all these schools. Those who have taken the course go back to their institutions and teach others how to use the equipment. At present, of the 150-odd problems being run by the machine, about 40 are from New England colleges other than M.I.T. The relative number is increasing, despite the greater difficulty out-of-towners experience in using the facilities, and it is hoped that eventually half the problems on the machine at any time will be from the other institutions.

Already the machine is busy helping to solve problems in a wide variety of fields of science, including anthropology, astronomy, chemistry, economics, engineering, geology, industrial management, mathematics, metallurgy, meteorology, modern languages, operations research, physics, and psychology. For example, as was reported in the newspapers, as soon as accurate visual sightings were reported, the orbits of the Russian satellites were computed by the machine; the results checked closely with those computed in Washington from radar sightings. In another case, the computer has been used to help establish the origin of peculiar glasslike fragments called tektites, which are found in various parts of the world, but do not appear to be of terrestrial origin. It has been suggested that tektites may be extraterrestrial particles that have been splashed off the moon by supermeteoric collisions, and peppered the earth millennia ago. The possible orbits of such particles have been calculated by the computer; the results seem to check with the distribution of tektites on the earth, though this does not prove their lunar origin. The Sputnik and the tektite problems have originated with the Harvard Observatory and the Smithsonian Institution.

To mention a few more examples, the M.I.T. Department of Meteorology has several large problems running concerned with weather prediction; the 704

is big enough and fast enough to begin to be able to compute the fantastically complex motions of air masses over the country, so as to predict what they will do tomorrow from what they are doing today. A member of the Applied Mathematics Department at Brown University is making more accurate calculations of the electron distribution in complex atoms. Members of the Nuclear Engineering Division of the Chemical Engineering Department have used the computer to help design neutron shielding for the new M.I.T. nuclear reactor, and will use it again to help determine the reactor's operating characteristics.

Each of these problems has required months of planning and coding before it was ready to be put on the machine. This pioneer work will help future users; many of the tricks of machine use and routines for computing various functions, developed for these programs, will be useful in other problems. An important task of the staff of the Center is to collect useful parts of successful programs, and to simplify and codify them so they can be used by others on similar problems. As time goes on, the task of programming will thus become easier.

In addition to computing, the machine can perform speeded-up or simulated experiments. For example, the probable behavior of a line of cars in a vehicular tunnel has been programmed. The machine is given the probable reaction of a driver to the behavior of the car ahead of him, as it speeds up or slows down or comes too close. These reactions have some random elements, so a preset randomness also is programmed into the instructions. Using these instructions, the machine then records the positions and speeds of each of the several hundred cars in turn and determines the position and speed each will have a second later. Going thus step-wise, the machine can work out the traffic flow pattern, indicating when hold-ups will occur and computing other over-all characteristics. In other words, the machine will simulate the actual traffic flow, will combine the assumed behavior of the individual units (the cars) to obtain the statistical pattern characteristic of the ensemble.

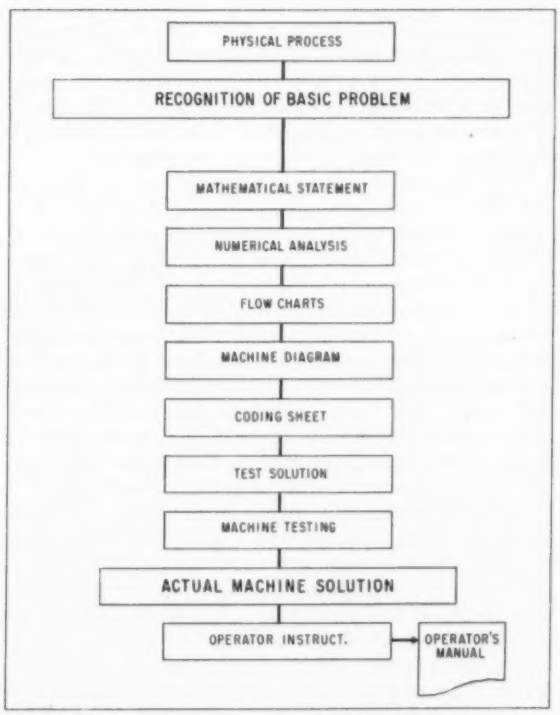
The procedure has many uses. If the statistical pattern coincides with measured data on actual traffic flow, we can be fairly sure our assumptions as to individual behavior are correct. Or we can vary the rules for individual behavior and thus see whether changes in speed limits, or required car spacing, or other unit behavior will improve the dynamics of the whole.

The M.I.T. Operations Research Group is also setting up a program to simulate the inventory system of a large industrial concern having hundreds of different stock items, several warehouses and with the usual variability of demand and supply. Here one can determine how various policies for stock reorder and shipment influence the probabilities of stock shortages, or the cost of inventory and of distribution, for example. New stock control policies can be tested in the laboratory, so to speak, instead of using the organization itself as the subject of the experiment.

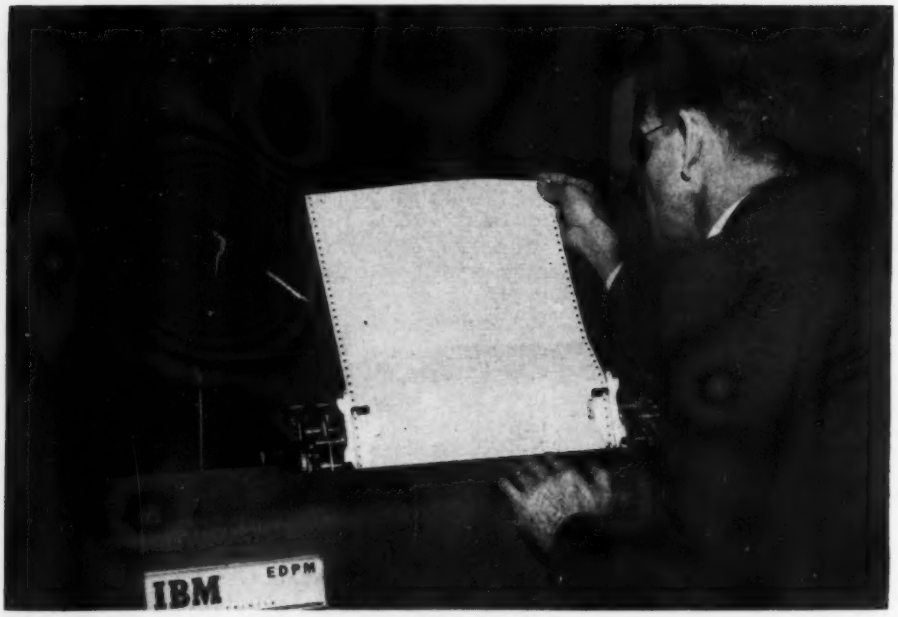
A group in the Economics Department at Harvard is working out an ambitious program to simulate the economic history of a segment of the population — the growth of a small town, for example. Working from the statistical behavior of individuals (their probability of salary raise, of buying a house, of marriage, and so on) as a function of age, salary, actions of others, and so on (including the inevitable random factors as well) they are programming the machine to work out the entire economic interdependence, the group dynamics of the selected population. To follow the histories of from 3,000 to 5,000 persons will take all the facilities of the 704, and very careful programming at that, to get answers in a reasonable time.

Although we can easily understand or specify the component parts of a complex system, we do not always (or, indeed, often) foresee all of the capabilities of the assembled system. This failing on our part makes necessary the job of the test pilot and explains why new automobile models are not always the wonderful performers they were expected to be. Chemists and physicists have long been aware that the understanding of the behavior of aggregations of atoms required more than a knowledge of the behavior of individual atoms. Gibbs, one of this country's foremost scientists, spent his life developing the theory of such large aggregates, called statistical mechanics.

Usually the mathematical techniques required to predict the characteristics of large aggregates are more difficult than the mathematics required to describe each part. Certainly, at present, mathematical techniques are inadequate to go back and forth from the characteristics of individuals (their preferences, capabilities, and interactions) as studied by the psy-



A schematic flow chart indicating the steps to be taken in getting the computer to solve a problem



The tabulator unit is one of the channels by which the 704 unit reports its results, in this case as letters, words, or numbers printed on a sheet of paper. Other direct output channels are the visual images produced on a cathode-ray screen; indirect output or input channels are the card-punch unit (opposite page) and the magnetic tape units. Two tabulator units are provided, one connected directly to the machine (on line) which is used for problems with a small amount of final answer.

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chologist and social scientist, on the one hand, to the economic and political behavior of large groups as measured by the Census Bureau or reported by historians, on the other hand. The use of machine simulation will be a powerful means of establishing such connections, of developing the statistical mechanics of social groups. Here the experimental techniques so useful in physics and chemistry are not possible; we cannot make a five-year experiment on a large group of people—at least not in this country. Computing machines, carefully and imaginatively programmed, may be able to take the place of the live group to an extent sufficient for the experiment, and the test may be run through in five hours instead of five years. The procedure has its pitfalls and difficulties, of course, but it is a promising one.

Machine simulation may also help shed light in the science of psychology. The human brain is a highly complex aggregate of nerve cells, each of which has fairly simple properties. How does such an aggregate remember, learn, or decide? Perhaps machine simulation studies – studies of the behavior of aggregates of simplified neuron responses – can help answer these questions even though the largest present computer has too few elements to simulate the complexity of a bird's brain, let alone man's. Some members of the Institute's Department of Mathematics are interested in these questions and plan to use the 704 to test some of their ideas.

But we have left our visitor unescorted, with some of his questions unanswered. What is this versatile gadget which is turning out to be so useful in so many scientific problems? Is it going to take over our thinking for us, as the automobile has substituted for our legs? To fear that eventuality is to misunderstand the functioning of an electronic computer. A machine like the 704 can really do only a few very simple things: it can count; it can remember; and it can compare. It can do these things much faster and more accurately than we can, of course, but that is all it can do. In three minutes it can do as much straight calculation – adding, multiplying, and the like – as would require a human computer (using a desk calculator) a month to do. It can store 10-digit numbers in its core memory, and retrieve them on demand in a forty-thousandth of a second, and do this several billion times without an error. And it can make the simplest sort of judgment – tell whether one number is larger or smaller than another – and base its next actions on the result.

It can do these things speedily and dependably, but this is all it can do. All the complex procedures of the calculations mentioned earlier must be built up laboriously by the programmer using these simple elements. And every action must be spelled out in detail. "Get this piece of data from storage register 113 and add it to what you have already; put the answer back in storage register 267; get the next piece of data from register 114, multiply it by two; if the result is larger than the number in register 1243, add it to the result in register 267; if not, return it and get the next number" – and so on, in endless and meticulous detail. Every possibility must be thought of; every time a division is ordered, the machine must be told what to do if the devisor is zero, for example. It is easy to see why it usually takes three months for a beginner to program a problem that the machine may run through in less than an hour.

It does not do to take a chance or to ask the machine to stop while you figure out what to do next. Machine time is too valuable for that; a minute's hold-up is equivalent to asking a human computer to wait a week while you make up your mind; the machine could be halfway through someone else's problem while you are figuring out what went wrong. Things do go wrong, of course. Many programs have "bugs" in them when they are first tried out. In this case the machine is instructed to print out where it was and what it was doing and then make

View of the machine which punches data and machine data instructions onto standard cards. The deck of cards, punched out via the keyboard shown here, is the basic form in which the user presents his problem to the 704; it is the visible result of his weeks of programming and coding. The on-line card reader translates the pattern of holes in each card into patterns of electrical pulses which are stored in the core memory for use in the next problem.

M.I.T. Photographic Service

itself ready for another problem. The unhappy programmer must take this "post-mortem" off to his office for diagnosis and come back later.

The digital computer is an immensely skillful, incredibly rapid booby, which will do exactly what it is told, but which has absolutely no judgment. It will carry out the intellectual drudge jobs for the user, but it cannot do his thinking. Any "reasoning" it is expected to do in a problem must be laid out in the programming. So the drudge work of computing is exchanged for the drudge work of programming – of laying out the steps of the computation, of translating the steps into the detailed orders, expressed in "machine language" and in punching these orders onto a deck of cards. No wonder only "tough" problems are put on the machine – problems for which the work of computing will be more tedious than the work of programming.

But this is putting the dilemma too strongly. For, if told to do so, the machine itself can do much of the drudge work of the programming. It can determine where in the memory it should store items of data and the intermediate results of its calculations; it can be told how to analyze program errors and how to print out "post-mortems" so the user can find his mistake more easily, and so on. Programs which tell the machine how to carry out much of the detailed bookkeeping of a finished program are called compiler programs. Members of the staff of the Center are busy devising better compilers to ease the work of the user. Their devising requires considerable logical subtlety and an intimate knowledge of machine behavior. After all, we are just learning what a machine of the complexity of the 704 can do.

For the computing machine itself also is a large and complex aggregate of fairly simple parts; it also displays characteristics which are hard to foresee, which require considerable study to understand fully and which thus are not yet employed as profitably as they could be. The language the machine "understands," the set of coded orders punched on cards, has a vocabulary and syntax which is troublesome to learn – though it is far simpler than any "human" language. The "words" and the "grammar" are imposed by the electrical and mechanical features of its design as much as by the logical requirements of what it is to do. It would be easier for the occasional user to be able to formulate his instructions in more familiar terms, closer to the language of usual mathematics, for example. As a matter of fact, it is possible to get the machine to do this translation.

The 704 has a complex program called "Fortran" (formula translation) which takes instructions in a more familiar language and translates them into instructions in "machine language." Instructions in Fortran require two machine actions to get an answer. First, the punched-card deck in "Fortran language" must be translated by the 704 into a proper program in "machine language," which is either recorded on tape or on a new deck of cards; this program is then fed back to the machine to get it to compute the problem itself and get the answer. Thus the machine does more work, but the machine user has an easier time of it.

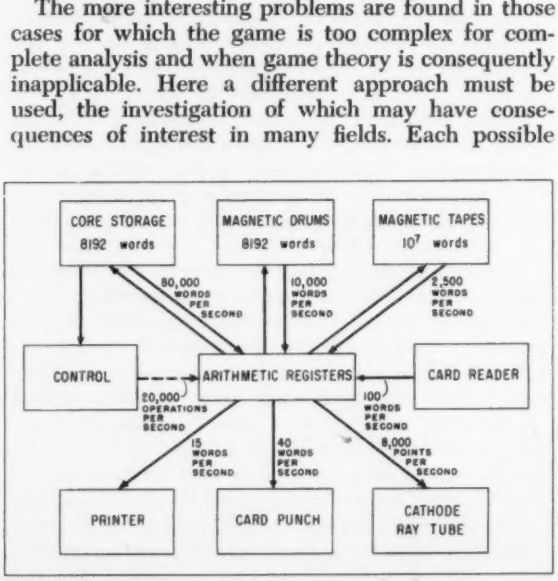
Parenthetically, the logical procedure useful in getting the machine to translate instructions from "Fortran language" to "machine language" is analogous to the procedures which would have to be followed if the machine were to be asked to translate a paragraph of Russian into English. Using a computer to translate from one "human" language to another is an immensely difficult task, and the results cannot be expected to be literature. But if machines can help translate into English the quantity of scientific articles which come out in other languages, the reduction of man-hours now spent in trying to understand what others have done will far overweigh the occasional clumsy phrasing of the

machine translation. Members of the staff of the Computation Center are co-operating with a group in the Institute's Department of Modern Languages to test some basic parts of this ambitious project.

Fortran has its limitations and drawbacks. There are some problems for which it is inadequate, for which it is best to use "machine language" directly. But we will be able to make improvements as we learn more of the 704's behavior patterns. Machine psychology is a popular field of research at the Center just now. Some of the staff of the Computation Center and some of the Electrical Engineering Department staff are co-operating to improve sensory and memory ability of the 704. The oscilloscope output, attached to the machine, will be connected, via a photocell, back to the machine memory again to see whether such an optical feed-back loop will make it possible for the machine to read a blueprint, or a page of type, for example.

Some of the ways of learning how the computer behaves are by programming it to play games. The 704 has been programmed to play ticktacktoe and also checkers against a human adversary; it is now being programmed to play chess, the Japanese game, go, and to run off several problems of business, athletic, or military competition which have structures similar to games. Such game-playing programs are of two kinds. The simpler, and less interesting, are for those games which are simple enough so that the consequences of every move and countermove can be foreseen. In these cases – the ticktacktoe is an example – all possible combinations are stored in the memory and the program instructs the machine which move to make in each possible situation. In these cases the machine is infallible – it always makes the best possible move – simply because the human programmer has included the complete situation, obtained by game theory or otherwise, in the program. The machine just has to work out the successive game theory solutions, as its adversary makes each successive move.

The more interesting problems are found in those cases for which the game is too complex for complete analysis and when game theory is consequently inapplicable. Here a different approach must be used, the investigation of which may have consequences of interest in many fields. Each possible



Schematic diagram of the functional parts of the 704 computer.

situation in the game, each configuration of pieces on the board in checkers or chess, for example, is initially evaluated with regard to its future advantage to the machine or player. This can be done fairly accurately for chess or checkers; experts at the game can rank-order the configurations in terms of chance of victory. The program then instructs the machine to move to the next possible configuration which has the greatest potential value.

Moreover, the machine can be programmed to improve on the initial evaluation by working out several moves of the game "in its mind" before it actually makes its next move. The opponent's possible countermove to the various moves it might make, then its possible next moves and the opponent's following countermoves for several steps in advance, may all be "thought out" in advance by the machine. It can then be programmed to choose that move which shows the greatest chance of reaching an advantageous configuration one, two, or more steps in the future. The present 704 can be programmed to explore three steps in the future in chess; when more core memory is installed next summer it may be able to look four steps ahead. Chess experts claim to look five or more steps ahead, so the machine cannot yet beat the champions, but it can usually beat the tyro.

In addition, the machine can be programmed to improve its game – to modify its program in the light of experience. The amount of learning possible at present is quite limited, but various improvements have already been suggested. Teaching the machine to improve its performance, on the basis of its own experience, has great promise, both practical and theoretical.

The process of looking ahead several steps in a process, of evaluating possible next steps in terms of expected future benefits, is called dynamic programming. It is a new branch of applied mathematics. Some of the basic mathematical theory has been worked out, but to speed up further developments a number of examples must be worked out in detail. Most such problems are too complex to work out by hand; they must be computed by machine. The techniques of dynamic programming will have wide application in industrial and military planning, as well as in the playing of chess and checkers. At present, members of the M.I.T. Operations Research Group are developing machine programs for various simple industrial situations involving the planning for purchase of raw material and subsequent manufacture, in the face of fluctuating prices and demands, for example.

Our visitor may conclude, at the end of his trip through the Computation Center, that in the near future an electronic computing machine will be considered to be as necessary to a university as a chemistry laboratory; ability to program for a computer will be as important a requirement for the B.S. candidate as ability to use a slide rule is now. Donation by I.B.M. of the facilities at the Computation Center has put M.I.T. and the co-operating institutions in New England in the forefront of education and research in the use of these new instrumentalities.

Business and Education: Mutual Survival

Dependent on one another while pursuing separate courses, business and education are moving toward each other in an atmosphere of growing mutual respect and understanding

by EDWARD McSWEENEY

THERE was a time, and it was not many years ago, when a businessman's interest in education – if he had any such interest at all – was likely to be somewhat superficial. He contributed money to his alma mater and perhaps to a few other educational institutions, recognizing in a vague way that the cause was worth while. When he retired, possibly, finding time on his hands, he accepted an invitation to join some nearby university's Board of Trustees.

The interest of educators in business was also quite superficial. In the academic view, the definition of a business was "an activity the sole purpose of which is to make money." There was nothing in this definition to indicate that businessmen were good for much of anything, educationally speaking, but the contribution of financial aid. Though it was generally recognized that most of a university's students would eventually earn their livelihoods in business, this fact was pushed into the background. Business and businessmen were viewed with considerable doubt and some scorn.

Happily, little of this is true any longer. Business and education are moving together in an atmosphere of growing mutual understanding and respect. They are doing so because they have to. With each of them, it is almost a question of survival.

In times as recent as the early 1940's, it was possible for a small handful of knowledgeable men to run a large company. It is hardly possible today. There has been a vast expansion in the amount of technical, economic, and other knowledge needed to keep a company in good health. No one man, no handful of men, can possibly have even a respectable fraction of this knowledge. Even in a small company there must be men who have spent their lives studying the physical sciences, economics and finance, graphic and literary communication. In a larger company, men are needed with backgrounds in psychology, languages, geology and geography, medicine, sociology and human relations. In short, as never before, business needs educated men – needs them in hordes. Without them, almost no business can hope to survive. The businessman *must* become interested in education. Adult education is an essential part of his business.

Tremendous strides have taken place in adult education as industry has grown in complexity and has become increasingly aware of the economic value of higher education. In the past half century, a wide variety of courses in adult education have become available in the larger metropolitan centers of the United States. Afternoon and evening courses, in particular, have grown in response to the needs of industry and technology. Some courses, such as the evening courses given at M.I.T. by the Lowell Institute School, aim to train men for supervisory positions; in other cases, college courses at the undergraduate or even the graduate level are available. Under certain conditions, it is even possible to obtain a bachelor's or master's degree upon satisfactory completion of a program of afternoon or evening study.

That business recognizes the value of education has long been apparent from the "on-the-job" training courses which many of the larger companies have established since World War I. In recent years, some of the larger firms, working in co-operation with nearby colleges or universities, have also developed new courses of instruction in advanced and highly specialized phases of engineering or the physical sciences. These are often given in the afternoon or evening, but some firms are encouraging programs of daytime graduate study for certain well-qualified employees. Recently, advertisements for technical personnel have also stressed the policy, followed by a few concerns, of offering scholarship aid to qualified employees who wish to take graduate degrees in their professional field.

In response to the highly specialized needs of modern industry, a new kind of educational co-operation with industry has evolved within the past decade. This is represented by the summer session courses, usually planned in co-operation with industry and given at a number of universities. Courses are usually taught by faculty members, but they have also been given by leaders in industrial technology. Instruction is usually given in the summer months when university personnel and laboratory facilities are not too heavily engaged in the customary academic program. The Summer Session courses offered at M.I.T. usually deal with topics at the forefront of present-day technological knowledge. Most of these courses are of short duration – a week or two – but a few have been longer.

The economic value of summer session courses is attested by their growth and by the fact that the number of applicants has frequently exceeded the facilities available. That business finds such instruction valuable is attested by the fact that, in nearly all cases, tuition costs are paid by the employer who

also pays the salaries of his employees who return to the college classroom.

Finally, a number of colleges have developed industrial liaison programs of one kind or another. Although the means of effecting such liaison varies, in all cases the objective is to bring industry and educational institutions into closer contact with one another, in keeping abreast of current technological advances. Frequently symposia and conferences, at the professional level, are arranged by the educational institution; in other cases, faculty members make trips to industrial organizations. The first procedure is employed by the Industrial Liaison Office of M.I.T., whereas the corresponding office at California Institute of Technology prefers the latter procedure.

In numerous ways, then, adult education is very definitely recognized as an essential part of modern progressive business.

The same kind of economic force is pushing the educator to meet and know the businessman. It is becoming increasingly apparent that government and private support are not enough to help educational institutions meet the often terrifying challenge of our growing population and growing demand for higher education. The states' educational appropriations increase year by year; tuition rates climb steadily; fund-raising campaigns grow more and more intensive. Still there is hardly a college president in the United States who today can be reasonably sure that his institution will be able to accept every qualified applicant for enrollment by 1960.

This statement is particularly true of privately endowed institutions of learning, whether at the elementary, college preparatory, or university level. Just as private institutions took the lead in advancing education in the colonies, so today we may expect them to be in the vanguard in promoting the nation's intellectual welfare. Private schools are relatively free from the pressures, toward conformity and mediocre performance, that the taxpayer sometimes advocates from a distorted concept of "democracy." The clamor for intellectual "equality" that sometimes marks discussions at Parent-Teacher Association meetings is less likely to sway the headmaster of a private school than the principal of a public school. Private schools have greater freedom to adapt their teaching programs to changing conditions, and, for the most part, they fulfill very well their obligation to foster quality of instruction.

Privately endowed colleges and universities should be expected to take the lead in maintaining high educational and intellectual standards. They are under no legal compulsions to accept every applicant who has been able to acquire a high school diploma. By emphasizing quality of instruction, they contribute mightily to the mutual survival of business and education. But privately supported schools and colleges can carry out their admirable missions only so long as they are able to remain solvent. As the real dollar value of investment return diminishes, and as taxes take an ever-increasing share of personal incomes, private schools must turn to other sources of income if they are to remain solvent while expenses rise. They cannot depend on the tax dollar to pay their bills.

The only financial force that can stop the onrush of state-supported "socialized" education seems to be business. Since business is the biggest user of what educational institutions produce, it seems quite just and reasonable that business should help in the pro-

(*Continued on page 314*)

M.I.T. Photo

"Business and education are moving together in an atmosphere of growing mutual understanding and respect. They are doing so because they have to. With each of them, it is almost a question of survival."

Except for the direct employment by industry of college graduates, probably no clearer link exists between the two than that of research in the physical and life sciences.

Shown at the left are two research workers delving into a problem of electronics in the new Karl Taylor Compton Laboratories which were opened for academic use last fall.

The Compton Laboratories Building is the administrative center for the Research Laboratory of Electronics and for the Laboratory for Nuclear Science at M.I.T.

Horse Power

Despite its important role in providing motive power, the draft horse has become a rarity in this country, and before long may well disappear into total oblivion

by FREDERIC W. NORDSIEK

SADDLE horses will, no doubt, ever be with us – steping daintily on bridle paths in city parks, emphasizing the authority of mounted policemen, performing in the "horse operas" of modern-day television programs – but draft horses, the massive beasts that once provided most of the overland motive power of this country, virtually have been banished from the scene by the inexorable pressures of economic obsolescence. Before the draft horse disappears entirely, it seems appropriate to take a retrospective, perhaps nostalgic, view of some of the curious lore that gathered about this animal during its century of ascendancy as a mobile power unit. For the draft horse's heyday did last just about a hundred years. Until the end of the Eighteenth Century, oxen were usually used for plowing and other heavy hauling. During the 1800's draft horses came into increasing, and finally into general, use; but then by 1910 steam power, electricity, and the internal combustion engine had prospered to the extent that horse populations thereupon started to decline – as they have ever since.

How Horses Haul

From the point of view of strength, speed, and endurance, man chose well in domesticating the horse as his erstwhile principal beast of burden in the temperate zone. Draft horses weigh more than 1,000 pounds, sometimes more than a ton; and a horse in good condition can easily exert a pull equal to its own weight. Such astounding muscular capacities have been measured accurately for draft horse contests; in recent times dynamometers have replaced the old-fashioned, stone-weighted sledges, once a familiar sight at county fairs. Using a dynamometer, a two-horse team weighing less than 3,000 pounds is officially recorded to have registered a pull of 3,325 pounds!

In passing, it must be acknowledged that the invention of a collar or breast strap, withal one simple in the extreme, enables the horse to exert its maximal muscular power to pull a load. This device was unknown to the ancient Romans, although they did have good horses. The harness used with Roman chariots employed a sort of belt clamped around the middle of the horse. With this contrivance the animals literally pulled their burden, and it took two or more of them to haul a chariot containing only the driver. The modern horse harness is based on a stiff padded collar encircling the horse's great neck and shoulder muscles; the animal pushes against this collar, thus readily bringing all of its strength into play, without constricting major blood vessels or exerting serious shearing action on the skin.

Anatomical Peculiarities

Any animal, even the human being, could be bred and trained to have strength and endurance; but the horse enjoys several unique anatomical features that especially suit him for his career as a beast of burden. Foremost of these attributes is the sturdy single hoof, possessed only by horses, asses (and their cousins, mules) and zebras. In evolutionary terms, this hoof corresponds to the nail of the human middle toe or finger. It is a thick mass of keratin, the exceedingly tough material of which human finger and toe nails and cattle horns consist. Like human nails, horses' hoofs constantly grow. In unshod animals running free on the open range, the rate of wear equals the rate of growth of the hoof. Unshod horses, confined to a barn or permitted only limited exercise, must have their hoofs trimmed every few weeks. Animals working on hard-surfaced roads or pavements, or pulling heavy loads on any surface whether hard or soft, must be fitted with horseshoes. If unshod, their hoofs would wear away faster than regrowth would provide replacement.

The horse bears his strong, tough hoofs at the end of legs that, in terms of human anatomy, have an extra joint. Thus, what looks like the hip or shoulder joint of a horse corresponds to our knee or elbow; the horse's real hip joint is hidden up among his great muscles. His knee joint corresponds to our ankle; his ankle to our toe joints. Much of the horse's mobility, speed, and power are due to this uniquely flexible leg structure, that exists in both its fore and rear legs.

Finally, the parallel-paired bones found in the human forearm and calf of the leg are, in the horse, fused into a single sturdy bone capable of sustaining great stresses. Broken legs are not unknown in horses, but they are relatively rare. Many of the leg stresses, commonplace to a cow pony working in a cattle roundup, would snap human legs like matchsticks.

A Tooth for a Tooth

The horse's teeth are unique, and are particularly well adapted to its way of life. Its molars grow up from the gum line as fast as they wear away at the

crowns. This eternally rejuvenated grinding equipment enables horses living in the wild state to subsist on natural grasses, however coarse and harsh, and enables domesticated animals to thrive on hay and unmilled grains. Horses, it should be noted, prosper on such tough and woody fare without the aid of the rumen, or extra stomach, that enables cattle and sheep to live on similar rations.

Man has exploited the arrangement of the horse's teeth in designing the bit, the metallic device inserted in horses' mouths to guide and control them. Bits rest in a toothless hiatus that exists between the horse's molar teeth in the rear of its mouth and the incisor teeth that lie right behind the lips. This toothless area is tender, so that the animals respond readily to pressures of a bit placed here. When a wily animal manages to work the bit back between his molar teeth, he can grip it there and resist all efforts to control him by the reins. That is why we say that a young person who acts independently of parental pressures "has the bit in his teeth."

A peculiarity of the horse that is a handicap to the animal, but helps man master the beast, is the horse's inability to breathe through its mouth. In consequence of this fact, a man who can restrain a horse's head enough to close the animal's nostrils with his hand, can subdue a beast having 10 times the man's size and strength.

Horse and Buggy Age

This, then, is the strong, swift, tractable – and to some eyes handsome and romantic – beast that provided overland motive power during the first century or so of this country's establishment and growth.

H. Armstrong Roberts

Horses pulled westward the covered wagons that bore the families and household goods of the American pioneers. No rations had to be carried for these animals, as the plains and prairies provided abundant grazing.

Once communities were established, horses took care of most of the local transportation. In cities, all deliveries were by horse and wagon; horses moved urban local passengers, whether by carriage, omnibus, or horse-drawn streetcar. Stagecoaches bore passengers, mail, and baggage across rough and dusty Western roads, negotiating steep grades and fording unbridged streams with utmost unconcern. After 1840, teams of fast trotting horses for light coaches flourished in the East, because adoption of the elliptical carriage spring, increasing mileage of smooth-surface macadam roads, and perfection of lightweight vehicles, made of sturdy American hickory wood, enabled rapid travel by horse and carriage.

Down on the Farm

Horses pulled the plows that broke the plains; they provided power for all of the other heavy work around farms; they hauled farm produce either directly to consuming areas or to the nearest canal or railroad.

The year 1910 saw the zenith of the farm horse in this country; that year there were 20,000,000 of the animals at work in American agriculture. Thereafter, farm horses began to be replaced slowly by power-driven machines. They became fewer and fewer in a slow but steady decline, until in the 1940's there occurred on American farms what Ezra Taft Benson has called a "technological explosion." This abrupt shift to almost totally mechanized farm methods virtually banished the last farm horses overnight.

A key to this violent change is man power; despite all of the horse's virtues, it requires much human attention to breed, train, and tend it. Man power has been steadily drifting away from the farm, making it necessary for proprietors to seek methods that minimize the requirement for human muscle and sweat. As a result, in the past 15 years production per farm worker has doubled. In 1820, about 70 per cent of the American labor force was in agriculture; today only 15 per cent is on the farms. This shift reflects a change from horse-powered to mechanized farm practices. Today, the farmer owning 40 acres of land and a horse barely can buy his groceries after paying off his hired help. But the farmer with 500 acres and the necessary mechanized equipment is prospering; the chances are that he has no hired help at all, but relies on his own family group for what labor is needed, including that required to run his machines.

On the American farm the last gasp of horsepower was associated with an attempt to minimize the element of human labor. Large teams, often including as many as eight horses were used for plowing, disking, and harrowing. With such rigs one man could guide the power of a half a dozen animals or more, and could, for example, double-disk 25 acres per day. With straining horses, creaking harnesses, clanking chains, cracking whips, and the driver's shouts, these big teams were an exciting spectacle; but the commonplace tractor, chugging undramatically along,

provides more power at less expense, and has ousted the big horse teams.

Towpath Teams

As the writer has shown on the pages of this periodical,* the main trade arteries of the United States during critical developmental years of the Nineteenth Century were the boat canals, such as the famous Erie Canal from Buffalo, N.Y. to Albany, N.Y. Let us not forget that the sole motive power of these vital avenues of transportation was provided by horses and mules. Working singly or in pairs, hitched in standard harness attached to long tow ropes, these animals plodded along towpaths beside the waterways and moved freight, commodities, and passengers in great volume for vast distances, and indeed made possible the early industrial development of this country. Some of the canal boats provided quarters not only for the crew but also for the team; a snug stable was built at one end of some of them. In the peak years of the canal trade, when various canals had to be operated around the clock, this arrangement permitted the working of horses in shifts. Boats were then supplied with two teams; one pair of animals would eat and rest aboard, while the other team pressed forward along the towpath and hauled the vessel onward. It was the economic superiority of the railroads that enabled them to put the canals out of business; and no small element in disfavor of the canals was the relative inefficiency of their motive power, the horse. By the early decades of the present century the old boat canals had lapsed into total desuetude, thus wiping out the need for vast numbers of horses that once plied their towpaths.

In Town and City

Amid the raucous huggermugger of present-day cities, an incongruous horse and wagon may occasionally be glimpsed when a junkman's cart rattles its dejected way along the street. Infrequently, the almost extinct equipage of horse and carriage may be witnessed along the peripheries of city parks, where battered and malodorous vehicles, usually piloted by equally battered drivers and drawn by sad nags, are available to take, for a brief spin along park driveways, anyone sufficiently nostalgic to pay an exorbitant rate and to endure the ancient smells of the carriages and their mangy carriage robes. But two once vitally important urban equine types have totally disappeared; the streetcar horse and the fire horse.

In the year 1886, near the peak of horse-propelled street railways, there were some 525 horse-drawn streetcar lines in this country, and more than 100,000 horses were used to pull their rolling stock. New York City's Third Avenue Line alone used 1,700 animals. Some large city carbarns made the only recorded attempt to mechanize, partially, the laborious and tedious grooming required to keep stabled horses in good condition. They introduced rotating grooming brushes, driven by flexible shafts attached to motors.

Each streetcar horse was on duty about four hours out of the 24, during which time it hauled a car not more than 15 miles, occasionally hitting a dizzy six miles per hour where the going was easiest. The rest of the time the horses spent idle periods in their stables – resting, sleeping, eating about 30 pounds of hay and grain each day, and periodically being groomed and shod.

Some streetcar lines sold their horses after about four years of service, replacing them with new, young, vigorous animals. As draft horses generally went to work at the age of about five, the retired horses usually were then some nine years old – late middle age for a horse. But great variability in longevity and vigor is true of all living things, the horse not least. Thus, one Chicago car line that kept careful records had an animal in service 22 years, to the ripe old age of 27! When retired, this veteran had worked on 8,545 days, and had hauled cars a total of 102,540 miles, or slightly more than 12 miles per working day, on the average.

In the foregoing section, it was told how horses were sometimes motive power for, and alternately, passengers on the old canal boats. Similar arrangements were occasionally used on hilly streetcar runs. On long downhill stretches, the horse climbed aboard, into a stall provided on the back platform; while the car coasted down by gravity, the animal rested for the hard haul back uphill. Such an arrangement could be used only on fairly gentle downgrades, however, for on steep slopes, or for sudden stops, the driver depended a good deal upon his horse to stop the car. In fact, when the first power-driven streetcars were built, their brakes were copies from those of the horsecars. These brakes proved to be totally inadequate and had to be redesigned, thus demonstrating the extent to which horses provided the decelerating action for horsecars coming to sudden halts.

The year 1872 was a black time for the horse-propelled street railways, as for all urban horse users. That year an epizootic of equine influenza, originating in Canada, swept into New England and New York, thence through the Middle Atlantic States, into Louisiana, and finally to the West Coast, destroying vast numbers of horses in its swath. In Philadelphia, some 200 horses died daily. In New York City, it was estimated that upwards of 18,000 horses were ill at the height of the pestilence. One New York streetcar line briefly hired crews of men – down-and-outers – to move its cars. Thus, fleetingly, this center of enlightenment witnessed the spectacle of men being hauled by men. This mode of transportation is usually regarded as a form of degradation and is ordinarily thought to be confined to the Orient with its jinrikishas, and the Atlantic City boardwalk with its rolling chairs.

Balls of Fire

The great Boston fire of November 9 and 10, 1872, with its loss of 14 lives and destruction of 776 buildings and personal property valued at $75,000,000 got

* "The Other Three," The Technology Review, **60**:159 (January, 1958).

out of hand because of the outbreak of horse influenza. How disastrous a fire covering 67 acres could be, during a horse epidemic, becomes clear when it is realized how much depended on the horse. Until well into the Twentieth Century, the Boston Fire Department – as all city fire departments – relied solely on horse-drawn engines, hauled by teams of horses weighing 1,200 and 1,600 pounds apiece. A team of these animals, responding to an alarm, tore through the streets at a full gallop, pulling a fire engine and crew weighing four tons. Starting springs were employed to get this vast weight rolling. The horses always were kept bridled, in open stalls. They were trained to leap to the shafts of the engine when an alarm sounded; their harnesses were suspended overhead, ready to be dropped into place. Within 30 seconds of an alarm, the engine was on its way.

Because of the violent physical demands made on fire horses, they never lasted for more than seven or eight years of service at the most, and then were retired to less demanding duties. Small communities, whose fire equipment did not require a full-time team, often kept horses on call at the local livery stable. One drawback of such a practice was that after some service at this assignment, the horses, ever creatures of habit, would bolt for the firehouse for the rest of their lives whenever an alarm sounded, even after their fire days were over and they had been assigned to sedate jobs, such as hauling peddlers' wagons or the carriages of wedding or funeral parties. The horse's good memory was sometimes useful, but often could be most annoying.

What's Wrong with Horses?

The foregoing highlights of the horse's heyday have brought out some of the shortcomings that, in time, made the draft horse obsolete. Although this beast thrives on a relatively inexpensive ration of oats and hay, it needs a lot of both, whether active or idle. Any horse is usually fed about a dozen pounds of hay daily per 1,000 pounds of body weight. The oats ration depends on the amount and kind of hard work to be performed, and ranges from about 10 pounds for carriage horses to 15 pounds for heavy draft horses per 1,000 pounds of horse. As we have seen, this input of fuel usually provides one horsepower for only about four hours out of the 24.

But a horse does not gain full size and strength until it is five or six years old; and during its early useless years it eats about as much as if it were working. The animal is next at its best for only the ensuing five years or so, then starts to decline in vigor – although some animals may remain useful to 15 or 20 years of age, and occasionally, as we have seen, even longer. Assuming a working life of 10 years, though, it is clear that a horse must be fed, housed, and tended for 15 years to obtain this 10 years of work output. And remember that, during the 10 working years, the animal is on duty only one-sixth of the time. Obviously the horse is an inefficient power-generating device!

Then, too, horses need constant skilled attention from human beings; and such services are expensive. The animals must be bred, helped through the perils of parturition, trained, protected from disease and treated for illnesses, housed, provided with bedding, groomed, and shod, their teeth tended, and their bulky excrement disposed of. Training alone demands a vast investment of human skill and time.

Higher Education

Remember that the horse is essentially a wild animal that readily reverts to the feral state when liberated in a suitable environment, such as the plains of the western United States or the savannas of British Guiana. Hence each new foal must be painstakingly "gentled," accustomed to the ways of man, and taught its necessary skills and tasks. Teaching a young horse to "lead" – follow a man holding its halter – alone requires eight or more half-hour lessons, begun when the animal is a few months old. The next lessons are devoted to teaching the beast to "yield" a foot; that is, to lift a hoof, stand still, and let a man handle the hoof as required for the necessary ritual of shoeing. Two men are usually needed for these lessons.

The next step in the horse's education is undertaken when it is about a year old. This is a prolonged and tedious procedure, usually requiring the services of two men, to accustom the horse to harness or saddle and to the bit, and to patiently teach it to respond to the reins and to voice commands, as required in the performance of the relatively simple maneuvers that are expected of the animal. These lessons are continued over the early, nonworking years of the horse's life. The precise amount of human time invested depends on the patience and skill of the trainer and on the educability of the individual animal, but at least the total hours required are many.

Temperamental and Timid

Variation in educability brings us to a most troublesome characteristic of the horse; its individuality. Standardized machines may be relied upon to perform fairly uniformly; but each horse is a law unto itself. According to their lineage, some of the animals are mostly gentle, others mostly wild and vicious; but all have their unpredictable moments, and each has an individual disposition.

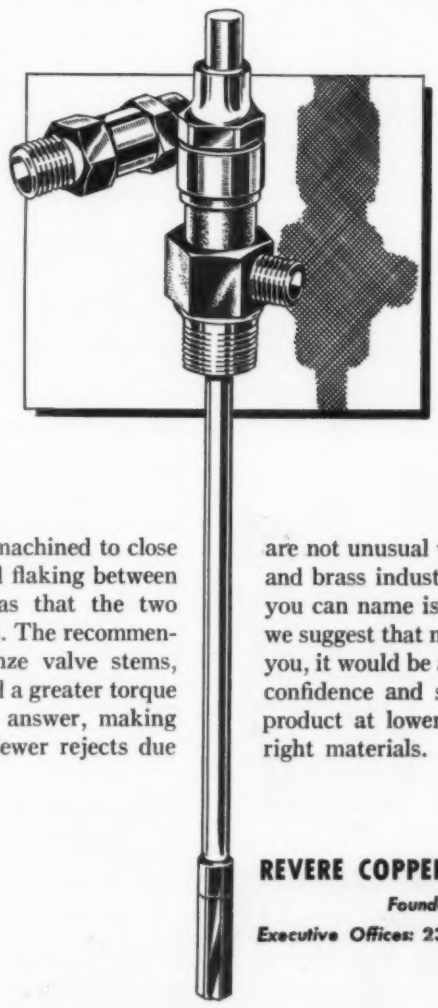
One inherited characteristic all horses share, however, is an extreme and foolish timidity. The primitive wild forebears of the modern horse had only one protection against danger; rapid flight. This is still the response of the horse to danger; and danger to this animal means anything unfamiliar. Hence the well-remembered scene of bucking, shying horses and runaway teams. Horses are frightened by any sudden, unexpected auditory or visual stimulus. Unfortunately the horse's eyes are so arranged that it can see to the rear about as well as to the front; hence it is startled by glimpses of the unfamiliar from any quarter. The blinders – leather flaps alongside the eyes – commonly worn by harness horses, reduce this hazard somewhat, but do not eliminate it.

(*Continued on page 312*)

BUSINESS IN MOTION

To our Colleagues in American Business . . .

In making gas pressure-reducing valves and relief valves for hot water tanks, a famous manufacturer has to drill brass rod deeply. Originally the rod was free-cutting brass. When we had the opportunity to study the operations in the shop it seemed evident that Revere's Deep-Drilling Brass Rod should offer some economies. When drilled, this alloy produces very small, easily cleared chips, much smaller than free-cutting brass. The latter is excellent for most applications, particularly for external machining, or for shallow drilling, but for really deep holes, deep-drilling brass is superior. So the customer agreed to try it. The results were most satisfactory. The shop foreman reported that tool life was increased over 200%. In addition, it is possible to bore one item with a single operation, against the former practice of withdrawing the drill three times in order to clear the chips.



Another interesting experience with the same manufacturer involves a high-pressure gas valve, with a cast brass body and a brass rod stem, both machined to close tolerances. There was galling and flaking between stem and seat. Our analysis was that the two brasses were too close in hardness. The recommendation: switch to arsenical bronze valve stems, which have a higher hardness, and a greater torque strength. This proved to be the answer, making possible a better product, with fewer rejects due to trouble at the seat. The more suitable alloy costs more per pound, but saves money in the end.

Here is a third example of our work with the same company. It was designing a new temperature-pressure relief valve for hot water tanks. The original model, hand-made for test purposes, had been machined out of solid hexagon brass rod, one inch outside diameter, and over half the weight had gone into scrap. It was recommended that on a production basis a Revere high-leaded brass tube be used, hexagon outside, round inside. A trial order of only 2,000 pounds immediately proved itself.

The customer reported that though the tube costs more per pound, he buys less weight per foot, machine time is reduced substantially, and a much better machined surface is obtained. The latter is extremely important on the inside of the valve, which is machined to a seat.

These examples of the wisdom of paying more per pound in order to make a better product and save money in addition are not unusual with Revere. Not only the copper and brass industry but practically every industry you can name is able to cite similar instances. So we suggest that no matter what your suppliers ship you, it would be a good idea to take them into your confidence and see if you cannot make a better product at lower costs by specifying exactly the right materials.

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HORSE POWER

(*Continued from page 310*)

Horses learn by repetition; by being rewarded with food when they do what is wanted, whipped when they do otherwise. Thus they learn merely to carry out the will of the driver, never to perform anything useful to mankind on their own initiative. The horse's limited intelligence — its "one-track" mind — is in part exploited by handlers. A horse that refuses to be led by its bridle is turned to one side; it becomes so engrossed in this maneuver that it forgets its disinclination to budge, and is soon under way. Conversely, runaways were sometimes stopped by merely turning them from a straightaway course.

The horse has a memory of sorts; it must of course remember the simple lessons that enable it to perform its appointed tasks. Who does not remember the milkman's horse, that in time learned to make all the stops of the route with no guidance from the driver. But the horse's memory combines with its extreme timidity to become a shortcoming. Once frightened by a particular sight or sound, it is forever terrified by this stimulus. Thus when electric streetcars first came into being, overhead wires or underground slots for the power lines, or even properly shielded third rails, were unknown. The current was carried either by each of the two rails as opposite poles of the circuit, or by a naked third rail. One reason why such arrangements were unsatisfactory was that they often inflicted painful, though usually not lethal electric shocks upon hapless horses. Once an animal had fallen victim to this terrifying indignity, it never again could be persuaded to cross streetcar or railroad tracks. This was a crippling handicap to the usefulness of any city horse, as in those days metropolitan streets were networked with trolley tracks.

The great Nineteenth Century horse influenza epizootic was a unique event; but all horses are continuously subject to a wide variety of infectious, parasitic, and degenerative diseases that are at best only partly controlled by the skills of veterinarians. The horse's skin, chafed by its harness, and its hoofs, bearing the stress of its weight and working drive, are subject to various special ills. A peculiar health hazard of the horse stems from the fact that it has no vomiting reflex. Hence if it inadvertently swallows toxic plants or other seriously unwholesome substances, it cannot regurgitate and hence may succumb.

Vested Interests

There are always some people who stubbornly refuse to co-operate with the inevitable, and every step of the horse's fall from favor was sturdily and articulately resisted by vested interests, including wagon and harness manufacturers, stable operators, and horse breeders. When smooth asphalt paving began to gain in use for city streets, to provide joltless passage for the new, fast-moving automobiles, organized demands arose from the horsy people for retention of Belgian blocks — those rough cobblestones that provided a bumpy upper surface on which horses' hoofs

(*Concluded on page 314*)

One of the three C-E LaMont Hot Water Boilers being installed at Forbes Air Base, Topeka, Kansas.

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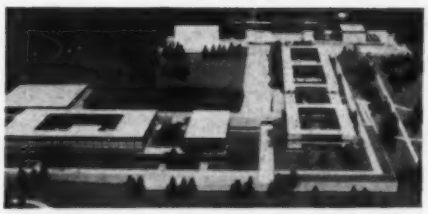

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HORSE POWER

(*Concluded from page 312*)

could get a good purchase. The first street railways and elevated railways were propelled by steam locomotives. Again a concerted wail arose from the horse interests because the strange-looking, noisy steam engines, belching smoke and steam, and with flying driving rods, sent runaway horses scattering in all directions. A compromise was arranged in the use of "dummies," or locomotives with the shell of a passenger car built around their exteriors. For many years these devices pulled the elevated railways of New York until the roads were electrified. Although just as noisy as regular locomotives, the dummies looked enough like the familiar passenger car to fool most horses, and to reduce substantially the incidence of runaways.

Draft Horses — a Rarity

Until fairly recent times, a Horse and Mule Association of America, Inc., maintained headquarters in Chicago and intensively propagandized for continued use of these animals for motive power on American farms. But despite all of the special pleading through the decades, the draft horses – expensive, malodorous, troublesome, temperamental, dangerous although timid, disease prone, and not very bright – has become a rarity in this country, and before long may well disappear into total oblivion.

BUSINESS AND EDUCATION

(*Continued from page 306*)

ducing. Moreover, support from business should be of the type that pays its full share of costs. Industrial grants may be a blessing to colleges when they pay the total costs of education for the project for which the grant is made. But grants that meet only a fraction of the direct costs of education, and none of the overhead or indirect costs, will surely send the college president out on a scouting mission, hat in hand. The Ford Foundation, with its mammoth grants, has already demonstrated one way in which business profits can find their way back into education. Many companies have established scholarships. Others, such as the General Electric Company and International Business Machines Corporation, offer generous provisions to help employees further their higher education.

Undoubtedly other kinds of machinery will be established in the future for expanding this kind of aid. The important thing is that the basic work has been done; the thinking of businessmen and educators has undergone the alteration necessary to allow for such co-operation.

This moving together of what were once two sharply divided worlds is not without its troubles, of course. There are many observers who imagine an unfortunate result. They fear that, as business and education become more and more closely associated,

(*Continued on page 316*)

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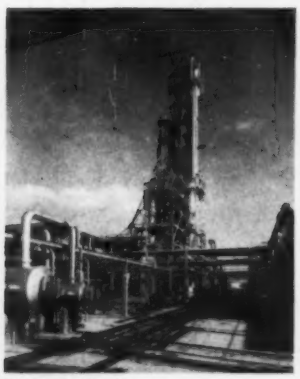
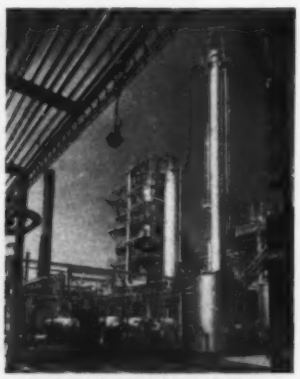


Ethylene Plant



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BUSINESS AND EDUCATION

(*Continued from page 314*)

business will take over education. Education will become "commercialized." The liberal arts and the humanities will gradually be shoved off the curricula to make way for "practical" studies – engineering, accountancy, economics, retailing, and other business specialties.

How well justified is this fear? In my opinion, it is not justified at all. Even in the unlikely event that business one day did get in a position to order educators about, no such thing would happen.

True, there is a shortage of engineers, and business would like to see more of these professional persons taught and graduated. Occasionally business firms seek graduates with bachelor's degrees in the expectation that such men will be immediately productive as soon as they are put on the company's payroll. By and large, however, business recognizes that the function of the colleges is to instill habits of thought, an intellectual curiosity, and a professional attitude, so that a man can build a professional career on firm foundations he acquired in college. Business recognizes that it must devote part of its activities to training men for their professions, and certainly business is much better able to provide industrial training than are the colleges.

But there is also desperate need for men trained in disciplines other than those of science and engineering, and this need is crystal clear to forward-looking businessmen. They recognize the need for persons trained in law as well as engineering, in humanistic endeavors as well as scientific, and in medicine as well as the "practical arts." Alexander Pope remarked long ago that the proper study of mankind is man. This is business' proper study, too. In the last analysis, the products and services created by business are created for people. If business cannot hire men who have studied men, business will be in bad trouble.

It is very easy to be cynical about business, to poke around and find a profit motive behind everything business does. It is much harder, but also much more rewarding, to see businessmen as men instead of walking ledger books. Most of them are educated men; many are scholars. To them, the teaching of man to mankind is fully as important as it is to educators.

I suspect, in fact, that many businessmen share with me the view that there is too much vocational specialization at the college level today. If this is a defect in our present educational system, it can be corrected. There are several ways in which our educational program might be modified and many able minds are devoting a good deal of time, energy, and thought to needed improvements.

Perhaps it would be better to put more emphasis on vocational training in high school. At the end of high school or a two-year community college, those who do not wish to go on to higher learning would be ready to step immediately into good jobs. Those who do go on to college could be introduced into broader fields of learning. Their vocational education

(*Concluded on page 318*)

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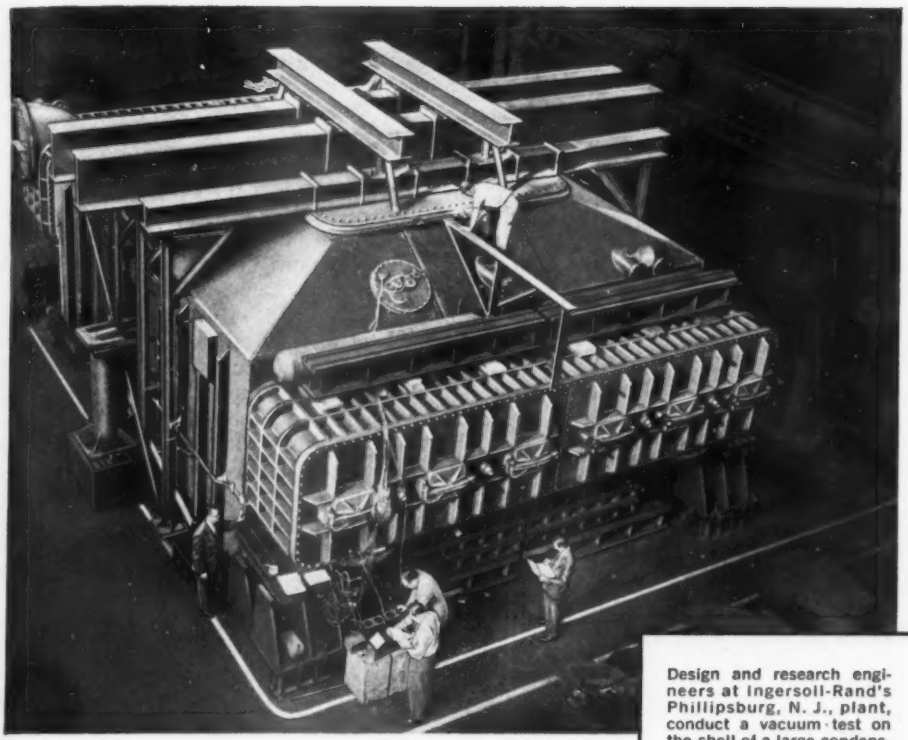

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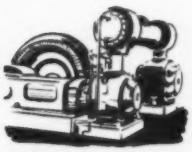

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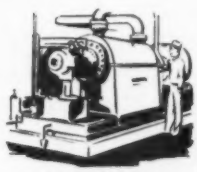

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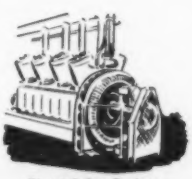

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BUSINESS AND EDUCATION

(*Concluded from page 316*)

would be a secondary part of their college careers instead of the primary one.

In this way, business would get what it really wants: men with a broad knowledge of many fields built on a vocational base. True, business needs specialists. But it does not particularly want the kind of specialist who knows nothing and sees nothing beyond the narrow confines of his specialty. Business wants men who can see and understand all the many factors of a problem, technical and human. This kind of man can best be developed, it seems to me, by making his education narrower at the start than in the later stages, by slowly broadening his view as he matures, even up to the graduate school level.

Education for business is in the final analysis education for management, and management leadership requires men of vision and strong intellectual powers. Business has given strong support to adult education for management, and many educational institutions have attempted to "cash in" on this interest by starting management courses that are poorly conceived and badly administered. It is hoped that the survey of the whole subject of training for management, sponsored by the Carnegie Corporation, will shed some light on this problem, although its findings will not be made public until sometime in 1959.

In the meantime, it should be evident to every businessman and educator that any roadblocks in the way of bringing business and education closer together must be removed. Two areas that are probably more psychological than factual are the businessman's distrust of the word "liberal" and the educator's over-use of the word "humanities." There is a good deal of evidence that while the educator is trying to define the humanities, the businessman is putting them into practice, with ever more liberal pension programs and all the other management "fringe benefits" that are the envy of the educational world.

The climate is improving, but much more must be done if business and education are to solve their mutual problems for survival.

TREND OF AFFAIRS

(*Continued from page 298*)

ing, but it is much more revealing when coupled with the study of information theory.

In his address, "Beyond Nuclear Physics," Dr. Livingston stated that energy greater than that which science extracts from the atom's nucleus lies hidden in the particles which make up the nucleus. Exploration of these particles is the principal purpose of the huge accelerators which have been built and are being built, said Dr. Livingston. Even more powerful ones are being planned to carry on research, according to Dr. Livingston, who added:

Particle physics goes as far beyond nuclear physics as that went beyond atomic physics and chemistry. We are

(*Continued on page 320*)

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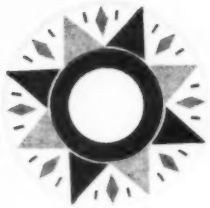

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TREND OF AFFAIRS

(*Continued from page 318*)

just at the threshold of exciting new discoveries about the fundamental particles of which the world is composed. Our basic goal is to learn the nature of matter itself.

If in the future some useful application to human needs comes from these beginnings, it will only be repeating our past experience and will again justify our faith in the ultimate utility of basic research and the search for knowledge.

The field of particle physics is basic research. There is no known area of practical application at present. The motivation of the university scientists is the search for knowledge about nature, at one of the extreme frontiers of science. The challenge is dramatic to an extreme, and advanced students are flocking into this field of science for their graduate studies and thesis problems.

The university is a proper location for such basic research, but because of the large apparatus requirements it is necessary to seek governmental support. All of us in the scientific departments and the institutional administrations are aware of the essential need to keep the scientific planning and management free from stultifying governmental controls.

At the luncheon, Sir Robert referred to the Russian's launching of its two Sputniks as "a beneficent Pearl Harbor." Believing that the roots of war are now growing, just as roots of the Battle of Britain and

(*Continued on page 322*)

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TREND OF AFFAIRS

(*Continued from page 320*)

Pearl Harbor were growing in 1938, he urged that greater attention be given to the nation's intellectual achievements. He left the impression that a nation whose families can afford more than one automobile and a television set can pay for its necessary educational expenses.

In the afternoon, Professor Schmitt opened the technical papers with his address on "New Frontiers in Molecular Biology." Dr. Schmitt related how giant squid, caught off the coast of Chile, are helping to disclose the biochemistry of all living things. In his speech, Professor Schmitt summarized various important developments in biological research and commented:

> The remarkable advances of modern molecular biology are a natural result of the application of physical and chemical methods of biology. The reaction is, so to speak, a spontaneous 'exothermic' one which, given enough time, technology, and tenacity may be expected to get to the bottom of the physical and chemical basis of life – at least at the lower levels of the micro-organism or the cell.
>
> This present period of highly profitable expansion of molecular biology may indeed come to be known to historians of the life sciences as the "classical age."

Speaking on "Twentieth Century Physics in the High Schools," Dr. Little stated that by 1960 more than 100,000 American high school students can be initiated into new concepts of physics. This is the target of a task force of teachers and scientists centered at M.I.T. – a group which is devising ways to bring physics education up to date.

A new course has been developed by the Physical Science Study Committee, and it is now being tested in eight high schools. Next summer, teachers from the eight schools, working with college and university physicists, will give instructions in this new physics course to 250 teachers attending National Science Foundation Summer Institutes at five colleges.

Many of these 250 teachers will introduce the course into their own schools next fall. It is hoped that they can give instruction to 2,500 teachers in similar institutes during the summer of 1959. And in the fall of 1959, at least 50,000 students will have a chance to study the kind of physics that is needed for dealing with the modern world of satellites, atomic energy, and hydrogen power.

Additional information on the work of the Physical Science Study Committee was given in The Review in the article "Educational Methods and Today's Science – Tomorrow's Promise" by Professor Jerrold R. Zacharias (July, 1957, page 501); and on page 250 in the Trend of Affairs section of the March, 1958, issue.

Highlight of the day's notable events were the addresses given at the evening banquet by the Institute's leaders – M.I.T. Acting President Stratton and Dr. Killian, Special Assistant to President Eisen-

(*Continued on page 324*)

SPECIAL REPORT

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EDUCATION: Williams College, B.A., 1942.

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PREVIOUS EMPLOYMENT: March '47—April '49, Salesman for national meat packer.

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TREND OF AFFAIRS

(Continued from page 322)

hower. Dr. Stratton emphasized that until very recently, engineering and technology rested far more heavily upon the practical arts than upon science itself. But, continued the Institute's Acting President, in addressing the Washington audience:

In our national concern to stimulate science, we may be overlooking and even neglecting the vital role of the engineer in our national progress. Engineers are not merely the draftsmen and plumbers of science. Our planes, our missiles, our great weapons systems, the stupendous growth and development of industrial processes are all the direct products of American engineering.

It is the American engineer who has been the chief architect of our industrial development, and the new industries that are springing up on every hand – and almost overnight – as a result of new advances in fundamental science. The applications of atomic energy alone are opening wide vistas of industrial development.

The engineer must have a feel for materials, a concern for cost, an understanding of the factors of weight and size, an appreciation of the problems of maintenance and repair, and, above all, an unfailing sense of responsibility toward his client and the public good.

As we move increasingly toward the theoretical and scientific in our engineering training, we must also concentrate on preserving these other qualities in the profession.

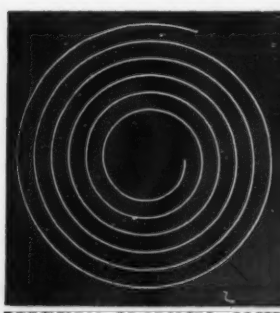
Speaking on "Underwriting the Future Strength of American Science and Technology," Dr. Killian stated:

I do not believe that we have lost our technological leadership nor that we are predestined to lose it in the future – provided we do not fail to remedy our weaknesses. We have great strength, we have great resources. . . . We continue to be outstai dingly strong in nuclear physics, in solid-state physics, in polymer chemistry, and in high-speed calculating machines.

The nation's requirements for sustaining and augmenting our research effectiveness were listed as follows:

The first of these is the need to make the adjustments in the level of support of research necessary to offset inflation and to meet new needs and opportunities.

(Concluded on page 326)



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TREND OF AFFAIRS

(*Concluded from page 324*)

Second, we need to stabilize the support of research by both public and private agencies. Starts and stops, *ad hoc* commitments, and modification of research programs have at times kept the national effort off balance, and have occasionally served to dissipate our efforts rather than to augment them.

Third, we seek to achieve a national policy and program for the provision of large scientific instruments, as for example in nuclear physics. Such a national policy and program seems essential if we are to achieve the best distribution of our financial resources. . . .

One of our most immediate tasks is to find mechanisms to make more generally known to the scientific community the availability of information already in hand. While we have problems of collection, we have greater problems in distribution. . . .

Next, we face the requirement that our American schools of engineering and our institutions of technology command more understanding and support. We witness the much-needed mobilization of national understanding and effort on behalf of medical education. We must achieve a comparable national effort in behalf of schools of science and technology, where inadequacy can be as perilous to the national welfare and safety as inadequate medical education. . . .

Because science is required for the maintenance of military strength and because it has made spectacular contributions to the development of weapons, it has come to be thought of with disproportionate emphasis on its military significance. This distortion needs correction, and it is heartening to note current efforts to re-emphasize the humane values of science and to underscore its immense contributions to the good life and the good society.

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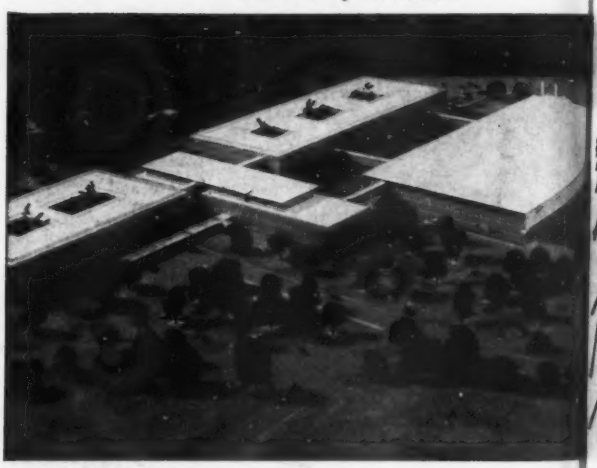

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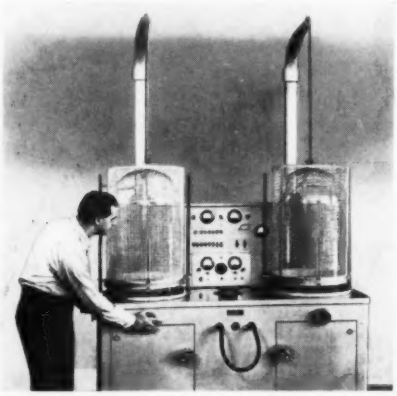

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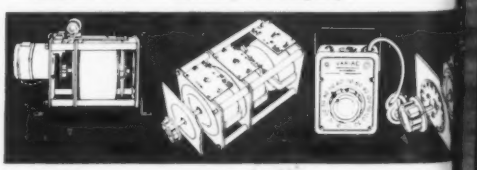

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